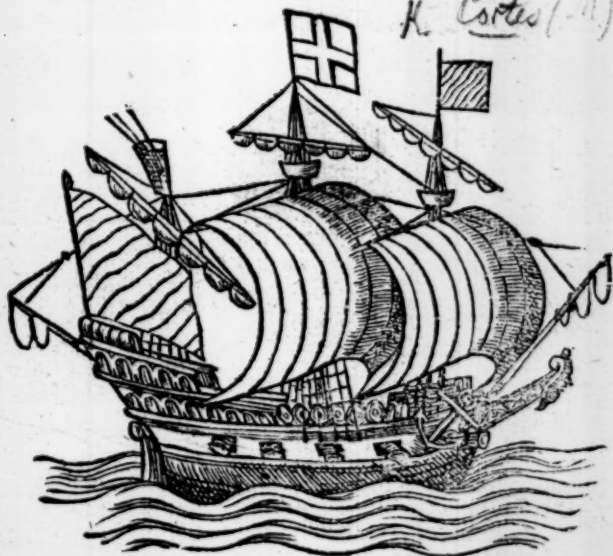


THE ARTE OF NAVI- GATION.

First, written in the Spanish tongue by
that Excellent Mariner and Mathemati-
cian of these times, MARTINE
CORTIS.

From thence Translated into English by *Richard Eden*: And
now newly corrected and enlarged, with many necessarie
Tables, Rules, and Instructions, for the more easie
attaining to the knowledge of Navigation.
By *John Tapp.*



Imprinted at London by *William Stansby*, for *John Tapp*, and are to
be sold at his Shop at *Saint Magnus Corner*. 1615.

6 FEB 68

THE NEWE,
ATTRACTIVE,
Shewing the nature, propertie, and
manifold vertues of the Loadstone,
with the *Declination* of the *Needle*, touched
therewith, vnder the plaine of the Ho-
rizon. Found out and discovered
by Ro: *Norman*.

WITH THE APPLICATION
thereof, for finding the true *Variation* of the
Compass: As also diuers profitable rules and
Instruments, for the more perfection
and exactnes in the Art of
Nauigation.

By maister *W. Burrowes*.



LONDON,
Printed by T. C. for *Iohn Tappe*, and are to be
sold at his shop at *S. Magnus* corner.

1614





To the Reader.



Any and diuers ancient Authors, Phy-
lotophers and others, haue written of
the *Magnes* or *Load-stone*, as also of the
substance, vertue and operation, and
therevpon setting downe their opini-
ons and iudgments, haue left the same
as infallible trutthes for them that
shall succcede. And as I may not, nor
mean not herein willingly to cōdemne the learned or an-
cient writers, that haue with great diligence laboured to
discouer the secrets of Nature in sundrie things, with
their operations and causes : yet I meane God-willing,
without derogating from them, or exalting my self, to set
downe a late experimented truth found in this stone, con-
trarie to the opinions of all them that haue heeretofore
written thereof. Wherein I meane not to vse barely te-
dious Coniectures or imaginations : but briefly as I may
to passe it ouer, grounding my Arguments onely vppon
experience, reason, and demonstration, which are the
grounds of Arts. And albeit, it may be said by the learned
in the Mathen aticalles, as hath beene already written
by some, that this is no question or matter for a Mechan-
itian or Mariner to meddle with, no more then is the
finding of the Longitude, for that it must bee handled ex-
quisitely by Geometrical demonstration, and Arithme-
ticall Calculation: in which Artes, they would hau all
Mechanitians and Sea-men to be ignorant, or at leaste
insufficientlie furnished to performe such a matter, alled-

To the Reader.

ging against the the latin Prouerb of *Apelles, Ne sutor ultra crepidam*. But I doe verily thinke, that notwithstanding the learned in those Sciences, being in their studies amongst their bookes, can imagine greate matters, and set downe their farre fetcht conceits, in faire showe, and with plawfible wordes, wishing that all Mechanicians were such, as for want of vtterance, should be forced to deliuer vnto them their knowledge and conceites, that they might flourish vppon them, and applye them at their pleasures: yet there are in this land diuers Mechanicians, that in their seuerall faculties and professions, haue the vse of those Artes at their fingers endes, and can applye them to their seuerall purposes, as effectually and more readily, the those that would most condemne them. For albeit they haue not the vse of the Greeke and Latin tongues, to search the varietie of Authors in those Artes, yet they haue in English for Geometrie, *Euclides Elements*, with absolute demonstrations: and for Arithmaticke, *Records* workes, both his first and second part: and diuers others, both in English, and in other vulgar languages, that haue also written of them, which bookes are sufficient to the industrious Mechanician, to make him perfect & ready in those Sciences, but especially to apply the same to the Art & faculty which he chiefly professeth. And therefore I woulde wish the learned to vse modesty in publishing their conceits, and not disdainfully to condemne men that will search out the secrets of their Artes and professions, and publish the same to the behoofe and vse of others, no more then they woulde that others should iudge of them, for promising much, and performing little or nothing at all. *Aristotle* saith, that euery man is best to be beleued in his owne professed Art and Science. Now (curteous Reader) I am to request thee to accept of this my discourse, wherein I haue taken some paines (as the trauaile it selfe may testifie) and beene at some charge, for the more carefull and orderly handling
of

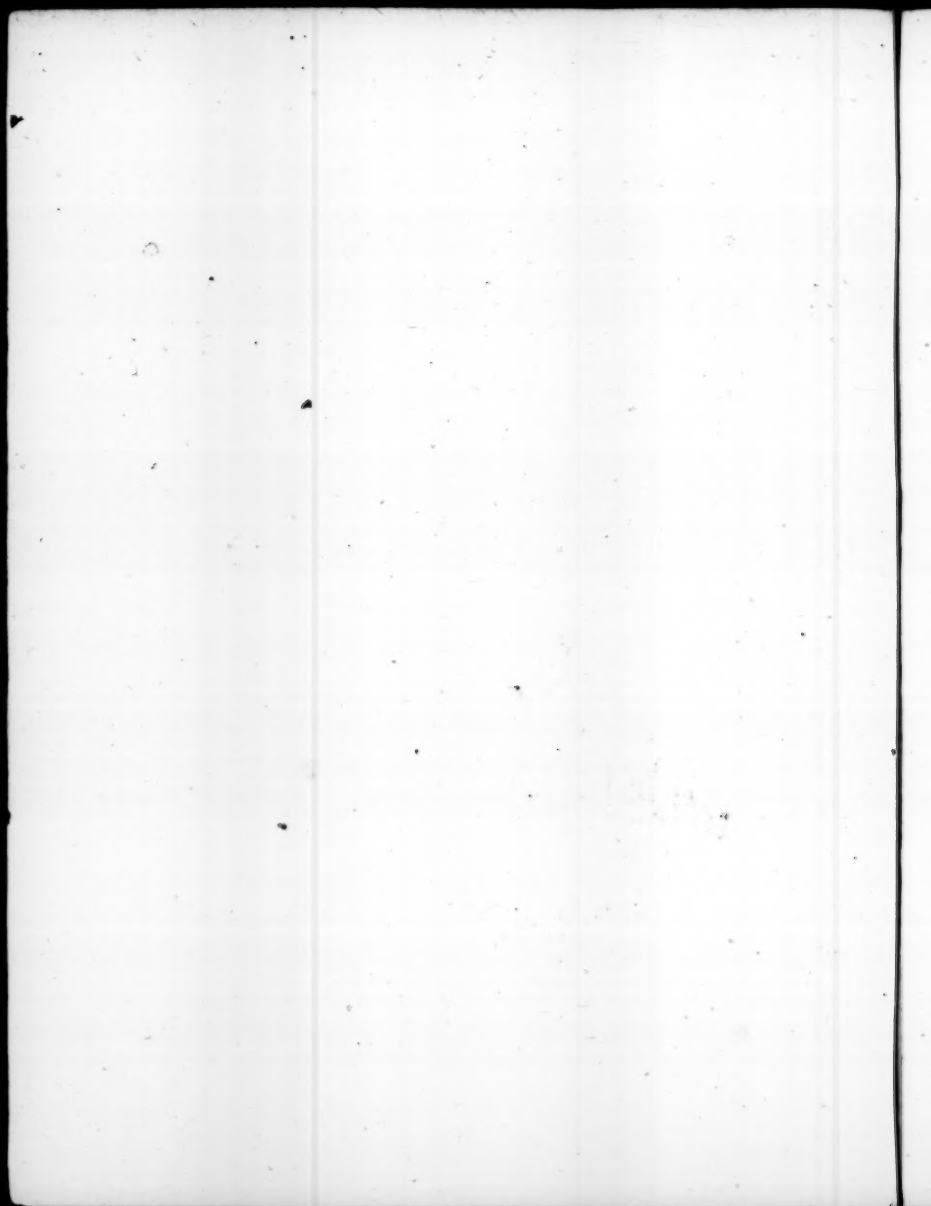
To the Reader.

of such matters as are necessarily incident to this present treatise: All which I haue bene content to doe, that the worke (though it be not big, yet effectuell) by the common vse thereof, may yeelde profit accordingly, to them specially that are of capacitie to comprehend this new reuealed secret. To conclude, the chiefeſt & onely marke whereat I lay leuell, was the benefiting of my Countrymen, in whom I wiſh continuall increaſe of knowledge and cunning, as in all other commendable profeſſions, ſo chiefly in thoſe that are moſt neceſſary and profitable. Thus bequeathing my trauaile heerein to thy diſcreet conſtruction, and wiſhing thy furtherance in this moſt neceſſarie and profitable knowledge,

I leaue thee to the direction
of Gods holy Spirit.
Fare-well.

Robert Norman.





The Magnes or Load-stones Challenge.



*Give place ye glittering sparkes,
ye glimmering Diamonds bright,
Ye Rubies red, and Sapphires brave,
wherinye must delight.
In brecfe yee stones enricht,
and burnisht all with gold,
Set forth in Lapidaries shops,
for Jewels to be sold.*

*Give place, give place I say,
your beautie, gleame, and glee,
Is all the vertue for the which,
accepted so you bee
Magnes, the Loadstone I,
your painted sheaths desie,
Without my helpe, in Indian seas
the best of you might lye.
I guide the Pilots course,
his helping hand I am,
The Mariners delights in me,
so doth the Merchant man.
My vertue lies unknowne,
my secret hidden are,
By me the Court and Common-weale,
are pleased very ferre.
No ship could saile on seas,
her course to runne might,
Nor compass shew the ready way,
were I Magnes not of might.
Bliss then, and comfort all,
bequeath to me that is due,
Your eates in gold, your price in plate,
which Jewellers doo reue.*

Its

The Magnes or Loadstones Challenge.

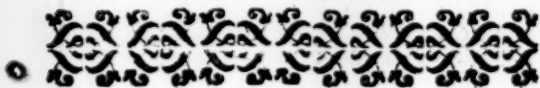
*Its I, its I alone,
whom you usurpe upon,
Magnes my name, the Loadstone calld,
the prince of stones alone.
If this you can deny,
then sceme to make reply,
And let the painefull sea-man iudge,
the which of us doth lye.*

The Mariners iudgement.

THE Loadstone is the stone,
the onely stone alone,
Deserving praise above the rest,
whose vertues are unknowne.

The Marchants verdict,

THE Diamonds bright, the Saphirs brate,
are stones that beare the name,
But flatter not, and tell the troath,
Magnes deserves the same.





THE NEW AT- RACTIVE.

CHAP. I.

Of the Magnes or Loadstone, where they are found, and of their colours, weight, and vertue in drawing yron or Steele: and of other properties of the same stone.



Magnes or Loadstone, is found in diuers partes of the worlde, and most commonly in yron Mines, and although it be ponderous & weightie, yet it is not found to be of the yron Ore, neyther containeth in it any mettall of it selfe, but hath a certayne affinitie vnto yron or Steele. It was called Magnes, because the first finder thereof was so named, who (as Plinie writeth) was an Heardsman in East India.

This stone (as writeth Cardinal Cusan) hath substance, vertue, and operation. His vertue is conserued & nourished of his substance: & of this vertue proceedeth diuers strange effects and operations, seruing to many good purposes, as specially in the Arte of Navigation, without which there could haue bene no Discoveries by sea, nor the parts of the worlde made knowne and frequented as now they are, and therefore the vertue of this stone of all others may bee accounted the most precious.

Of these are diuers sortes differing each from other, as well in goodnesse, as in colour, weight, and force, but not in propertie, (although many haue iudged the variation of the Stone, to be according to the distance of the Mine where the Stone was byed, to the place where hee is used.)

The new Attractione.

The best
Load-
stone.

Next the
best.

The first & best sort of these stones come out of the East India, from the coast of China, and Bengalia, and is of the colour of yron or sanguine colour: these stones are very massive & weightie, and will draw or lift up the iust weight of it selfe in yron or Steele (if the stone excede not a pound weight.) And these are of the finest sort, and are sold commonly for their proper weight in siluer in the East India, where they grow, because the best and finest are very rare to be found. For it is commonly a sole stone, lying by himselfe in the earth, and no shell or pece of another.

There is another sort of a reddish colour found in Arabia and the red Sea, growing broad and flat, much like to a Tilestone or Slate: this is not so weightie as those of China, but it is very nare as good, and the vertue continueth long on the COMPASSE or Needle that is touched with it.

There is likewise of these stones in Leuant, in the Isle of Elba, hard by a towne in the same Ilande called Porto Feraro, from whence our Mariners daylie bring of them, and are called there Calamita Preta, that is to say, The blacke Magnes, because there is another sort that is white and light, like unto a pece of dry fallers clay, and is called Calamita Blanca.

This Calamita Blanca is founde allwayes with the other, sticking fast in the out-side thereof like clay. And this white is forbidden to be used in that Country, because euill Women there, doe applie it to destroy conception, whereof this stone is a great enemy. Other things are noted of this white Calamita, for obtaining of wanton purposes, which I thinke not credible, and therefore will omit it. These blacke stones of Elba are mingled with white beynes, they are of no great force, nor their vertue of long continuance.

Also there are of these stones in high Almaine that are full of holes like an honeycombe, and lighter then the other, but yet very good: and these are of yron colour.

Another

The new Attractive.

Another sort there is in Norway, in the yron Mines, as in Longsounde, and other places, their colour is blacke, The mixed, or as it were interlarded with gray, these are of the worst. smallest force of any that are found.

I haue scene also in the Mines of Carauaca in Spayne of a gray colour, but of no great force: these are commonly brought by horse downe to Siuill and Callis to bee sold, and oftentimes to Valentia, Alicante, and Lisbone.

All these stones are different one from another, as well in force, as in colour and weight: yet all of one operation in the Needle, shewing one poynt Attractive, as I haue proued my selfe by thre sundry sortes of them, which I haue: and all drawing yron to them. Yet the Philosopher Auerroes writeth, that the Magnes draweth not yron vnto it, but the yron of his naturall inclination moveth to the Stone.

And though this position may seeme to carry some trueth with it, by the bare view of the sight, when the yron is lighter then the stone: yet contrarywise you shall finde that the Stone will moue to the yron, if the Stone bee good, and the yron of greater weight then the Stone (so that the weight of the Stone excede not his Attractive strength.)

Nevertheless, wee may not thereby take away the vitall or lively spirit from the Stone, and attribute it vnto the yron: for in so doing wee should doe Nature greate wrong. For it is apparant, that the yron hath no Attractive vertue nor power of it selfe, vntill it haue receiued it of the Stone. But yron hauing a certayne affinitie, or naturall qualitie agreeable to the Stone, doth aptly and freely and naturally receiue his vertue, and as a subiect, suffereth his vitall spirall spirit of the Stone to impresse, and rest quietly in his massie and open and solide bodie, which when it hath receiued by touching ration of the Stone, it is indued with the very same propertie and the Load-operations in all respects (though not in so great force) as stone. the Stone it selfe.

The new Attractive.

For as the Stone hath power to shew the Attractive point, so hath the touched Iron. As the Stone hath two principall pointes, so hath the Iron. And likewise, as the Stone hath power to draw Iron to it, so will the Iron so touched, draw another Iron to it, and impart all these vertues to another Iron in qualitie, though not in quantitie: and thus in all respects it containeth in it, the verie proprietie of the Stone.

Paracelsus writing of the augmenting of the Strength of the Magnes Stone, saith, that if this Stone be layde in the fire, untill it bee almost redde hot, and then taken out and quenched in the Oyle of Crocus Martis, it will so augment and multiplie his force, that it will pull a nayle out of a wall. But I suppose he meant not that the nayle should be fast, for then it were a miraculous matter.

Others have writtten, that in those parts, where the Magnes groweth in the Sea, it is of such force, that if any Shippes that have Iron in them passe by, or over them, that they are presently either stayed, or drawne downe to the bottome by reason of the Iron. Not these onely, but many other fables have bene writtten by those of auncient time, that have as it were set downe their owne imaginations for vndoubted truthes, and this most of all in Geographie and Hidrographie, or Nauigation. Wherefore I wishe experience to bee the leader of Writers in those Artes, and reason their rule in setting it downe, that the followers bee not led by them into errors, as oftentimes haue bene sene.

True it is, that God is mightie and maruellous in all his woorkes: yet he doeth not allowe vs to say more then truth of them. And truly, his power is as greatly shewed in the Magnes, as in any Stone that hee hath created: and who so shall goe about curiously to seeke out the efficient cause of his properties, I suppose the longer hee seeketh, the more he shall maruell, and yet neuer the nearer his purpose.

The

The new Attractive.

The vertue of the Stone is distributive, as many other vertues are, much comparable vnto Muske, that hauing a sweet sauour or smell it selfe, imparteth the same to another thing, as to a payre of Gloues, and those Gloues giue out sauour, and perfume a whole chest of cloathes: Euen so the yron that hath receiued this vertue of the Stone, will extend, and giue the same to another, and that yron to another, and so to many.

And in this point the Stone is maruellous, that notwithstanding you touch ten thousand yrons or nailles with him, euery one of them carryng away as much vertue as will lift vp another his like (so they exced not the weight of a sixe penny nayle) yet the Stone it selfe will be nothing diminished of his strength, but continue of one force.

If I should say heere, that by the Attractive strength of a small Magnes of two or thre pounnd weight, I could lift vp, or cause to hang by the vertue thereof, a thousand pound of yron at one instant, peraduenture you would be doubtfull of the successe. Neuerthelesse, by experience in all things, wherein consisteth trueth and reason, of necessitie reason must yeld, when trueth is present. And therefore because you shall not remaine doubtfull herein, thus you may doe it, and onely make p^{ro}ofe by two or thre nailles, if you will: for the same successe that you haue in them, you shall haue in all the rest.

Take a common wood nail, & touch the head of it with the north parte of the Magnes or Loadstone, then take the same nayle, and beate it with a pece of wood lightly in to some poste or timber upwards, so as the head may hang downewards, (but not with yron, because the yron will take away some part of the vertue from the nayle:) this done, take another like nayle, and touch the head thereof with the South parte of the Stone, and then if you put the head of it to the head of the first nail, it wil hang fast by it a whole pece or more. And after this manner you may, if you will take the paines, hang a hundred tun of yron with

The new Attractive.

the vertue of this little stone, and yet the stone nothing diminished of his force. But it is necessarie in proue of this matter, that you haue a very good stone.

Irons to
hang one
by ano-
ther by
vertue
of this
stone.

Furthermore, concerning the other properties of this stone, if you put it in a dry dish, and sette it to swimme in a tub of water, it will turne the dish about, and the North parte of the stone, after many swarings to and fro, will rest, and directly shew the line of Variation, or imagined Attractive point.

Also, if you hang this stone by a thred, that it may easily moue, it will shew the like effects as on the water. And if you haue two stones, putting the two South partes of them together, the one will fly and turne away from the other, and likewise of the North pointes.

A speciall
note.

And further yet shall note as a speciall point, that the North point of the stone touching a Needle, or the wyers of a compasse, will make the same point touched to shew the South: and contrariwise, beeing touched with the South point, wil make the same to shew the North. So as alwaies that part of the stone that answereth to the north of the needle, is properly the South part of the stone.

CHAP. II.

Of the diuers opinions of those that haue written of the Attractive point, and where they haue imagined it to be.



He subtil properties and hid secretes of Nature in the Magnes, as also in diuers other things, hath so troubled the wits of the searchers thereof, that alwaies when they came to the vphol, wanting experience, and thereby reasons finger to shew them a direct marke, they were constrained to seeke or imagine a marke, where indeede none at all was, and thus shooting

The new Attractive.

thoſting as it were in the aire, euery man where he thought beſt, they haue all ſhot wide, and none touched the marke. The marke I meane heere, is the point Attractive, or rather, as ſhall be ſaide heereafter moze at large, the point Reſpectiue.

This point, aunciently called the Attractive point, hath bene by ſome imagined to be in the morning ſpheres diſtant from the poles of the world: which opinion Martin Curtes in his Wooke of Nauigation refuting, ſaith, that if it were ſo, then the ſame point beeing carried about the pole by their violent motion, would cauſe the needle or Compaſſe touched with the vertue of the Stone, to varie daily in euery place, according to the diurnall motion of the ſame ſphere. But in confuting the erronious opinion, he hath (as it appeareth) fallen into as great an error himſelfe: imagining the point Attractive to be beyond the poles of the world, without all the moueable heauens. Which point (ſaith he) hath power by Attraction to draw yron to it, that is touched with the Loadſtone. This error I reſerre to be diſcuſſed in the ſixt Chapter.

Others haue taught this point to be in the earth, nere the North pole, imagining in that part to be ſome great rocks of the Loadſtone, & that by their Attraction the compaſſe or needle is cauſed to Reſpect or ſhew that part.

This opinion of all the reſt is eaſieſt to be confuted by daily experience: for if the compaſſe or needle were drawne towards the North part by any Attraction of the Magnes ſtones in thoſe parts imagined, why then ſhould not the Compaſſe or Needle ſhew the ſame effect in morning towards the Iſland of Elba in the Leuant ſeas, where are great quantitie of theſe Stones: and yet Whippes ſayling within a myle of this Iſland, yea, and into Porto Feraro, a Towne of the ſame Ile, within a quarter of a myle of a huge Rocke of theſe Stones, the Compaſſe or needle is not found any thing to be drawne or changed, nor the Attraction of this huge rocke to extend ſo farre as one

The new Attractive.

quarter of a myle. And as I haue said by this, so may I say by euers other places where the Loadstone are found in Cliftes and Spines nate to the Sea side, as in Norway and other places.

Pedro de Media, in his booke of Nauigation, is of the opinion of Martin Curtes, as touching the Attractive point, but he doth not allowe of the variation of the compassse or needle, but saith, that if the compassse or needle shew not the pole, the fault is in placing the wires on the side, and not in any propertie it hath to vary.

These opinions be diuers, but the chiefest cause why they haue gone so farre wide from the Attractive point, as I haue aboue said, was because they wanted reasons fingeres to shew them towards the direct marke. By this reasons finger, I meane a certaine Declining propertie vnder the Horizon, lately found in the needle, which I will entreate of at large.

CHAP. III.

By what meanes the rare and strange Declining of the Needle, from the plaine of the Horizon was first found.



Being made many & diuers compasses, and vsing alwaies to finish and end them before I touched the needle, I found continually, that after I had touched the yrons with the Stone, that presently the north point thereof would bend or Decline downwards vnder the Horizon in some quantitie: insomuch that to the flie of the Compassse, which before was made equall, I was still constrained to put some small peece of ware in the South part thereof, to counterpoise this Declining, and so make it equall againe.

Which effect hauing many times passed my hands, without

The new Attractive.

without any great regard thereunto, as ignorant of any such propertie in the Stone, and not before having heard nor read of any such matter: It occurred at length that there came to my hands an Instrument to bee made, with a Needle of five inches long, which needle after I had polished, cut off at just length, and made it to stand leuell upon the pinne, so that nothing rested but onely the touching of it with the Stone: When I had touched the same, presently the north part thereof Declined downe, in such sort, that being constrained to cut away some of that part, to make it equall againe, in the end I cut it too short, and so spoiled the needle wherein I had taken so much paynes.

Whereby being stroken into some choller, I applyed my selfe to seeke further into this effect, and making certayne learned and expert men (my friends) acquainted in this matter, they advised me to frame some Instrument, to make some exact tryall, how much the needle touched with the Stone would Decline, or what greatest Angle it would make with the plane of the Horizon. Whereupon I made diligent proofes: the maner whereof is shew'd in the Chapter following.

CHAP. IIII.

How to finde the greatest Declining of the Needle vnder the Horizon.



Take a small Needle of Steele wiew, of five or six inches long, the smaller and the finer mettall the better, and in the middle thereof (crosse the same) by the best meanes you can, fixe as it were a small Arctræ of yron or brasse, of an inch long, or thereabout, and make the ends thereof very sharpe. Whereupon the Needle may hang leuell, and play at his pleasure.

Then provide a round plaine Instrument like an Astrolobe,

The new Attractiue.

lobe, to be diuided exactly into 160. partes, whose diameter must be the length of the Needle, or thereabout, and the same instrument to bee placed vpon a sorte of convenient height, with a plumme line to sette it perpendicular.

Then in the Center of the same Instrument, place a peece of Glasse hollowed, and against the same Center vpon some place of Brasse that may be fixed vpon the sorte of the Instrument, fit an other peece of Glasse, in such sorte that the sharpe endes of the Areltræ beeing bozne in these two Glasses, the Needle may play freely at his pleasure, according to the standing of the Instrument.

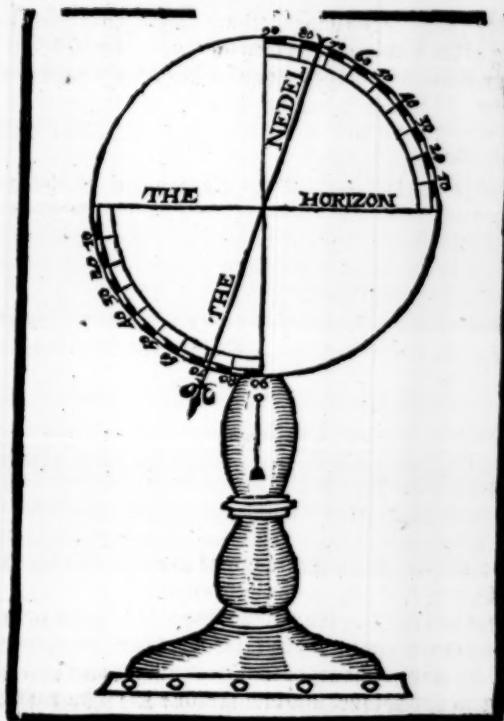
And the Needle must be so perfected, that it may hang vpon his Areltree both endes leuell with the Horizon, or beeing turned, may stand and remaine at any place that it shall be sette: which being done, touch the saide Needle with the Magnes Stone, and set the Instrument perpendicular by the plumme line, and turne the edge of the Instrument South and North, so as the Needle may stand duely according to the Variation of the place: which Variation the Needle of his owne property would shew, were it not that he is constrained to the contrarie by the Areltree.

When shall you see the Declination of the North point of the touched Needle, which for this Citie of London, I finde by exact obseruations to be about 71. degrees 50. minutes. The forme of the Instrument heere described with the manner of the declination, I haue heere placed that it may be the easier conceiued.

The



The new Attractive.



CHAP. V.

That in the vertue of the Magnes or Loadstone, is no pondrous or weightie matter, to cause any such declining in the Needle.

BEcause the opinions of men are diuers, and the arguments of many against reason, peraduenture there are some will say, that I am deceiued euē in the ground & chiefeſt point of this my purpose, alledging
(as

The new Attractione.

(as some haue already done without reason) that this Declining of the needle, is caused by some pondrous substance that it receiveth from the Stone, and not (as I take it) to proceede of the simple vertue and secret influence thereof, but in the stone it selfe wherein the vertue remaineth and is nourished, is weightie.

I iudge the learned will not allowe a Spirit to haue any co^r. or all substance or weight, or that it may sensibly be felt: if any should, yet by two conclusions it is easily proved, that the vertue of this stone containeth in it no weightie matter: and thus found.

Take three or foure small peeces of yron or Steele my^r. er, and putting them in a fine gold Ballance, counterpoise them in like with Leade: Then take them out and touch them well with the stone, that they may receive the vertue thereof: And after weigh them againe in the same ballance, with the same leade, and you shall finde them to weigh no more then before they were touched, though e^uery one of them haue retained vertue sufficient to lift vp his fellow.

Secondlie, if the South point of the Needle doe Decline by any pondrous or weightie matter, in the vertue received by touching the Stone, why then should not the South point of the needle, being touched with the contrary end of the Stone, haue the same declining Southwardes, beeing all one Stone, and one vertue? Or why doth not this supposed beauiet end, fall perpendicularly to the Center, as by reason it should, and not couet a certaine scituation beside it, ballancing it selfe by and downe, till it haue found the same? These arguments may answere this matter. For touch the Needle with what part of the Stone you like, that end of the Needle that betwix the South, will alwaies decline.

CHAP. VI.

A confutation of the common receiued opinion of the point Attractione.

Seeing

The new Attractive.



Seeing it is manifest that there is a Declining in the needle, & that the same is not caused by any ponderous waightie matter in the vertue receiued from the stone: it may be demanded, by what means this declining or eleuating hapneth, & in which of the two poynts consisteth the action or cause thereof.

Peraduenture you will say: (as other haue imagined) that it is in the South point of the Needle, eleuated by the Attractive vertue of some point of the Heauen that way. Perchaunce you will yeld it rather to bee in the North point of the Needle, which by some Attractive point in the Earth, or in the Heauens, beyond the Earth that way, is drawne downe and caused to decline, and it Declining, of necessity the other South poynt opposite must needs be lifted vp.

Your reason towards the earth carrieth some probability, but I proue that there be no Attractive, or draweing propertie in neyther of these two partes, then in the Attractive poynt lost, and falsely called the poynt Attractive, as shall be proued. But because there is a certayne point, that the Needle alwayes respecteth or sheweth, beeing voyde and without any Attractive propertie: in my iudgement this point ought rather to bee called the point Respectiue.

And further if it may be proued, that there is no Attractive or draweing propertie in that poynt, the power & action in that poynt condemned, then of necessity the power and propertie, without any externall cause, remaineth onely in the Stone, and after in the needle, being touched with it, hauing the same power and propertie in it, that the Stone hath in euerie respect.

Now to proue no Attractive point neither beneath in the earth, nor Heauens Northwards, nor about in the Heauens Southwards, you shall take a pece of Iron or
Stale

The new Attractive.

Steele wier of two inches long or more, and thrust it into a peece of close Cork, as bigge as you thinke may sufficiently beare the wyer on the water, so as the same Cork rest in the middle of the wyer.

Then you shall take a deepe Glasse, Bowle, Cuppe, or other vessell, and fill it with fayre water, setting it in some place where it may rest quiet, and out of the winde. This done, cut the Cork circumspectly by little and little, untill the wyer with the Cork be so fitted, that it may remaine vnder the superficies of the water two or thre inches, both ends of the wyer lying leuill with the superficies of the water, without ascending or descending, like to the beame of a payze of ballance being equalie possed at both ends.

Then take out of the same wyer without moving the Cork, and touch it with the Stone, the one end with the South of the Stone, and the other end with the North, and then set it againe in the water, and you shall see it presently turne it selfe vpon his owne Center, shewing the aforesayd Declining propertie, without descending to the bottome, as by reason it should, if there were any Attraction downewards, the lower part of the water being nêrer that point, then the superficies thereof.

And as this may proue no Attraction or drawing downewards in like maner the Cork being so made, that it may sinke very slowly to the bottome, and then taken out and touched with the Stone, and put in againe downe to the bottome with your finger, if any Attractive drawing were vpwads, it would ascend, and come vp to the superficies of the water, being nêrer to that poynt than the bottome. But I finde by diligent and exact tryall, that it hath no such effect: as in the figure following is demonstrated.

Again,

The new Attractive.



Againe, if you doe fit your tryer with Corke, that after it is touched with the Stone, it will swim leuill in the superficies of the water, you shall see it turne to shew the true Variation, and leauing the same in the middle of the superficies of the water, so long as you list, you shall finde that it will not bee drawne from his place, neyther to the
one

The new Attractione.

one side, noꝛ the other, whereas if there were any suche Attractione point as haue beene imagined, either in the earth by vertue of huge Rockes of the Magnes Stone neere the Pole, oꝛ otherwise in the heauen, oꝛ wheresoeuer, by what meanes soeuer, beeing but the twentieth parte of the force that the Needle touched, hath to shew to Respective poynnt, it should of necessitie be oꝛ at one in time to some side.

So that vpon these experiments I conclude, that the Attractione poynnt before imagined, is no where, noꝛ no such thing: and therefore, as most proper, I will call the poynnt whereunto the Needle inclineth by vertue of the Stone, The point Respective, and attribute the whole power of shewing that point to bee in the Stone, and in the needle, by the vertue received of the Stone, which vertue must bee imagined to bee turned, boꝛne, and depending vpon his owne Center, as shall bee shewed in the next Chapter.

CHAP. VII.

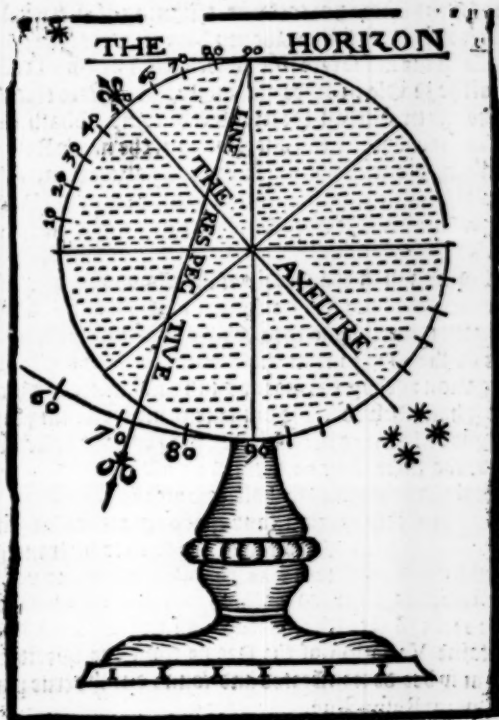
Of the poynnt Respective, where it may bee by greatest reason imagined.



This poynnt Respective, is a certayne poynnt, which the touched Needle doeth allwayes Respect oꝛ shew, and is found by the declining of the needle, to bee a picke in some one parte of a straight line, declining in this place oꝛ Latitude of London vnder the Horizon 71. degrees, and 50. minutes, as the Figure following representeth.

This

The new Attractione.



This straight Line must be imagined to proceede from the Center of the Pable, into the Globe of the Earth, Extending, and going Directly forth, both wayes infinitely. But in what part of this Line the point Respective is, it is not by this bare Line alone to be answered: no more then it is possible by one bare Angle to know the measure or Distance of any place assigned.

¶

And

The newwe Attractive.

And for the finding of certaine assigning of y^e true place of this point Respectiue, we must leaue vntill the expert traualler haue made certaine obseruation of this Declining of the Needle in other places. For seeing it is certaine that though in seuerall Horizons, the compasse hath seuerall Varations: yet in any one Horizon, the needle Respecteth alwayes one onelie point without alteration, as by trauaile is truelie proued. So I iudge, that in his Declining, it keepeth the like order and certaintie in euery place.

And although the Needle of the Compasse, by reason of the weight of the heauie flie, cannot Decline, as his propertie is, but falselie sheweth the point Respectiue alwaies in the Horizon, as most necessarie so to doo for the Navigation: yet by the meanes and conclusions, whiche before I haue shewed, the diligent traoueller hauing with him a good Magnes or Loadstone, may by exact obseruation finde the increasing or decreasing of this Declining of the needle, as the trauaile shall giue occasion.

For I am of this opinion, (and that by great reason) that this Declining of the Needle shall bee founde by trauell to be great or little, according as the distance of the point Respectiue, is from the place where the triall is made: whiche beeing diligentlie obserued in sundrie places, with the certaine Variation of the Needle from the Meridian, thereby may bee demonstrated and found out the true place of this point Respectiue.

CHAP. VIII.

Certaine proofes that the power and action is wholie and freelic in the stone, to shewe this point Respectiue: and in the Needle, by vertue & power receiued of the Stone: and not forced or constrained by anie Attraction in heauen or earth.

The new Attractive.



It is most manifest in all the works of Nature, or Creatures that God hath made, that whatsoever Qualitie, Propertie, or Vertue is founde in them, by Creation, that is to be holden for the stone. And he that shall, by imagination or conjecture, go about to take these their Properties from them, and attribute the same to any other subject, whereunto they appertain: I say that man offendeth God much, so; not believing his Power to be sufficient in his Creatures.

I will not offer to dispute with the Logicians, in so many pointes as heere they might seeme to over-reach us in Naturall causes. But that this Stone hath wholly and fully in himselfe, Power, Reason, Propertie and Vertue of his owne Appetite, to helpe, and to cause the Steele to strike the point Respectiue, without any Attractive qualitie, or externall cause of Rocks of the Magnes-Stone, or by Attraction in the Heauens, or else where whatsoever, it is already sufficiently proued.

Notwithstanding, if these proofes may not content, I will at any time required haerein, satisfie the doubtfull, by manifest Experimentes. And therefore where no other cause can be probably annexed vnto this Stone, the power and action of necessity is proued in in selfe.

And by the Declining of the Steele, is also proued, that the point Respectiue, is rather in the earth then in the Heauens, as some haue imagined; and the greatest reason why they so thought (as I iudge) was because they neuer were acquainted with this Declining in the Steele, which doubtlesse if Martin Curtes had knowne, hee would not haue iudged the Attractive point to haue bene in the Heauens, or without them, but rather in the Earth.

Now peraduenture you will aske me howe this Stone hath his Power, and how it is engendred: I am no more able to satisfie you here in, then if you should aske me howe

The newwe Attra&tiue.

and by what means the celestiaall Spheres are moued: but that **G D D** in his Omnipotent prouidence hath appointed it so to be; which may serue for a generall answer to all such curious searchers of the secreete workes of God in his creatures. As though his Word alone were not a sufficient Decree and law to all his workes: but binding them to second causes, as a thing of necessitie.

These curious searchers out of the secrets of Nature, further then is requisite that man should knowe for his necessary vse, I may compare to Eldras, and with them to read ouer his fourth booke: and there they shall see how he was answered at Gods handes by his Angell, for his curious Questions asked and demaunded.

I will therefore, as I haue before declared, that dyuers haue whetted theyr wits, yea, and dulled them, as I haue mine, and yet in the ende haue bene constrained to flie to the corner-Stone: I meane **G D D**, who (to conclude) hath giuen Vertue and power to this Stone, proper in it selfe, to helpe one certaine point, by his owne nature and Appetite, and not subiect to any other accident in Heauen, nor in Earth, but freely by his owne proper vertue, receyued at his mighty hands in Creation: and by the same vertue, the Stone is turned vpon his owne Center, I meane the Center of his Circular and inuisible Vertue, piercing all thinges, and stayed by nothing, be it Wall, Worde, Glasse, or any thing whatsoever.

And surely I am of opinion, that if this Vertue cou'd by any means be made visible to the Eyes of man, it would be found in a Sphericall forme, extending rounde about the Stone in great compasse, and the dead bodie of the Stone in the middell thereof: Whose center is the center of his aforesaid Vertue. And this I haue partly proued, and made visible to be seene in some manner, and Godsparing my life, I will herein make further Experience, and that not curiously, but in the feare of God, as nere as he shall giue me grace, and meane to annexe the same vnto a Booke of

Pauliga.

The new Attractive.

Navigation, which I haue had long in hand.

CHAP. I X.

Of the Variation of the Needle, from the Pole, or Axeltree of the Earth: and how it is to be vnderstood.



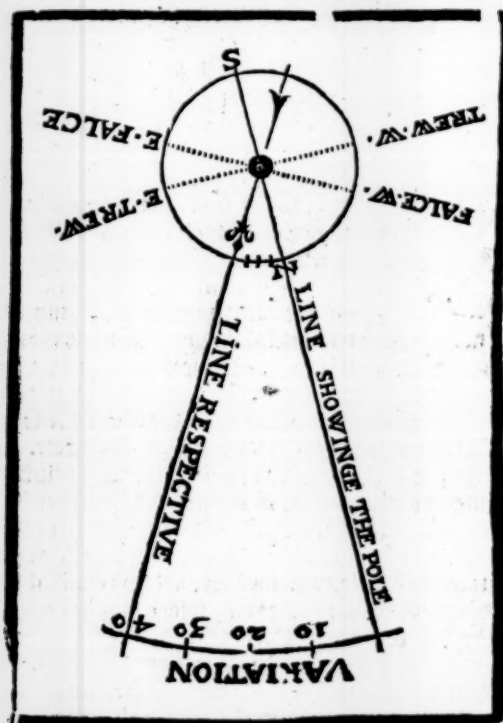
Now, as the Needle hath this apparant property in Declining vnder the Horizon, to shew the point Respective: So it is most manifest, that as in Declining it hath property in varying, or departing frō the Poles, euen as the point Respective openeth, or sheweth a greater, or lesser distance betwixt the sayde point Respective, and the Pole or Axeltree of the Earth. And this departing is called Variation of the Needle. This is also shewed in the Needle or Water, in that conclusion of declining in the Water, as in the first Chapter, euen by the same proportion, that it sheweth in the need'e Horizontally.

This Variation is no other thing, then a certaine parte or portion of a Circle, contained betwixt two straight lines proceeding both from one Center, which may be imagined to be the Center of the Needle, and from thence both extending and going directly south: One to the Pole or Axeltree of the world, and the other to the point Respective, and this part of Circle contained betwixt these two lines in the Horizon, is saide to be Variation.

And further here is to be noted, that alwayes these two Lines haue two right Lines, cutting them directly in the Center of the Needle. The one of them crossing the Meridian, at right Angles in the Center of the Needle, is the true East and West of the World. And the other crossing the line Respective at right Angles, is the false East and West that the varying Needle or Compass sheweth: all which is shewed by this present figure following.

This

The new Attractive.



This Variation is adjudged by diuers Travellers to be by equall proportion, but herein they are much deceyued: And therefore it appeareth, that notwithstanding they Travell, they have more followed theyr Bookes then Experience in that matter. True it is, that Martin Curtes doth allowe it to be by proportion, but it is a most false and erroneous Rule. For there is neither proportion nor Uniformity in it, but in some places swift and sudden, and in some places slowe.

The new Attractive.

It is said to be proportionall of vniforme, when in the increasing or decreasing of a degree of Variation, is found one certaine number of Leagues or Miles, going, increasing, or decreasing in one Paralell or Latitude, by like equall proportion, and that if the Variation be doubled, going by one Paralell, so shall the leagues or miles also. But this is not found to be so.

For in going from Silly to Newfound-land, which is not 600. Leagues, it is found that the Needle doth varie more in 200 Leagues, when you come nere that Countrey, then it doth in 400. Leagues of your first way. And also going to Meta Incognita, it varyeth more in parte of the last of the way, then in 3. parts of the first, and in those partes it is found to be suddaine. Further it is found betwene the North Cape and Vaigatz very strange, in recouling and comming backe againe to the Westwardes of the Pole, befoze it hath fully accomplished two poyntes of Variation in the compasse. So that at Vaigatz it varyeth to the Westwardes, as it doth at Newfound-land. And this comming backe againe, befoze it hath accomplished foure poynts of the Compasse, is very strange, and against the opinions of all that haue befoze written.

Because the Line of the Needle that sheweth the Pole Arktic, and point Respective, by vertue of the Stone, passeth betwene Sillic & Newfound-land.

Pedro de Medina (as I haue said in the second Chapter) was doubtfull of the Variation, saying: that if the Compasse did varie, the fault might bee in the making thereof, the Myers or Needle not being well placed: yet hee was a Learned man, and a great Traveller to the West Indies. But it appeareth that he had no more regard to the Variation, then many Mariners in these dayes.

For in 18. or 20. years that I haue travelled the Seas, being daylie conuersant with manie of them, and diligent in Enquiring of Variation of the places, where I haue not beene my selfe, I could neuer finde two of them in one truth, except for the Trauailes from hence Southwardes, and South Eastwardes. But I suppose the greatest occasion thereof is by lacke of exacte Instruments for

The newe Attractive.

that purpose. Wherefore I haue deuised one very necessarie.

And further, because this Variation is diuers, and is found sometimes to the Eastwards, and sometimes to the Westwards of the Pole, I will declare what the Variation is here in London, by mine owne obseruation, and in other places, as I haue grossely gathered of some Trauellers, reckoning, or beginning at the ancient bound or great Meridian, that passeth by the Ile of Saint Michael in the Açores: where it is saide, that the Needle sheweth directly the Pole, and the Respective point both in one line. But this is not found to be so.

True it is, that the North point of the common Compass, sheweth the Pole very nare in that Meridian, but the bare Needle sheweth about 4. Degr: 50. Min: to the Eastwards of the Pole. So that you must vnderstand alwayes the difference betwene the common Compass and the Needle, to be at the least 1. third part of a point, & of some more: because the greatest parte of the common Sayling Compasses, hath the Needle set in the fyfe, halfe a point, or 2. third parts, to the Eastwards of the North, and some 3. quarters of a point, and others at a whole point; and some againe, are set directly vnder the Flowerde-Luce, or North of the Compass: those are called Meridionall-compasses, because they shewe directly the Pole, in the great Meridian: as the bare Needle doth, which Meridian must needs be at the least an hundred, or an hundred and twenty leagues to the Westwards of the Ile of S. Michael.

And therefore to write of the Variation of places, by the common Repoztes of Harryners that haue trauelled Southwards and Westwardes from hence, it shall be as vncertaine, as are the diuers makings of these common Compasses, by which they haue made their Obseruations. And therefore I will omit it, and speake only of this place or Citie of London, whose Latitude I finde to be 51. degrees, 32. min: and the Variation of the Needle from this Meri-

The new Attractive.

Meridian of the Pole to be 11. Degrees, 15. Minutes.

And although this Variation of the Needle be found in Trauell to be diuers and chaungeable, yet at any Land or fixed place assigned, it remaineth alwayes one, still permanent and abyding. And therefore I with the Partner to make diligent obseruation of this Variation in diuers places, as he shall Trauell, by some exact Instrument for the purpose. For it may be greatly for his aide, againe he come there another time, especially in such places where the Variation is swift, as in these South parts. And because the common Compass is partaker of this Variation and Declining, as the Needle is, I will somewhat shew of the sundry sorts and makings of them, with the inconueniences that may grow by them, and by yll plats, made by these diuers sortes of Compasses.

CHAP. X.

Of the common Compasses, and of the diuers different sortes and makings of them, with the inconueniences that may growe by them, and the Plats made by them.



If these common Sayling Compasses, I finde heere (in Europa) five sundry sortes or sets. The first is of Leuant, made in Scicile, Genoua, and Venice: And these are all (for the most parte) made Meridionally, with the Vipers directlve sette vnder the South, and North of the Compass: And therefore, duely shewing the poynt Respectiue, in all places, as the bare Needle. And by this Compass are the Plats made, for the most part of all the Leuant Seas.

Secondly, there are made in Danske, in the Sound of

The new Attractive.

Denmarke, and in Flanders, that haue the Wyers set at 3. quarters of a point to the Eastwardes of the North of the compasse, & also some at a whole point: & by these Compasses they make both the Plats: & Ruters for the Sound.

Thirdly, there hath bene made in this Countrey particularly, for Saint Nicholas and Ruscia, Compasses set at 3. seconds of a point, and the first Plats of that Discoverie were made by this Compasse.

Fourthly, the Compasse made at Seuil, Lisbon, Rochell, Bourdeaux, Roan, and heere in England, are most commonly set at halfe a point: And by this Compasse are the Plats of the East and West Indies made for their Pilotages, and also for our Coastes neere hereby, as France, Spayne, Portugall, and England: and therefore best of these Platons to bee vsed, because it is the most common sorte that is generally vsed in these Coastes. And againe, it is saide, that the middle hazard is best.

I speake thus, because there are so many sortes of these Compasses different eache from other, as before I haue declared. And the Master or Mariner sayling by these Compasses of sundry sortes, may thereby fall into great perill, and the reason is, because that of long time these Compasses haue bene vsed, and by them the Marine Plats haue bene described of sundry sortes, euery one according to the Compasse of that Countrey.

If then hee take not the Compasse of the same sette or making that the Plat was made by, then his Carde or Plat will shewe him one course, and the Compasse when hee thinketh he goeth well, will carry him an other way. And thus, when he thinketh to fall with the place that his Carde sheweth him, hee shall be as farre wide, as the Compasse hee hath sayled by, is different from that his Plat was made by.

This is the ground and cause of many inconueniences, which is now too late to be generally reformed: Therefore I wish the Mariner to haue a great regard vnto this,

The new Attractive.

as a principall poynt in Pauiation, and not to Sayle by a Compasse of one patih, and a Plat of another: I meane that they haue a respect, as nere as they may, to Sayle by a Compasse of that countrey, where his Plat was made.

Yet many there are that vse our Compasse with Leuant Plats: but I suppose without good consideration therein, they shall make but wide reckonings. And this hath bene sufficiently of late experimented, by our Warri-ners that haue vsed Leuant.

Peraduenture there are some will say, that he knoweth a good Compasse, if hee see it; I say the Compasse may be good, and yet not good for him, except his Plat be agreeable: As for Example: A Leuant Compasse is a good Compasse, to vse with a Leuant Plat, but it differeth from our Compasse halfe a point more Easterly. And others there are of Danske, that differ from ours 1. halfe point more Westerly, and yet being vsed in their kinde, are good Compasses.

And therefore I conclude, that generally the best Compasse is this sorte set at one halfe point, because the maiore parte of Compasses and Plats doth not differ from this above one quarter of a point: except the two abouenamed, Leuant, and Danske.

I haue heard many say, that haue travelled farre to the Southwardes, that the Compasse hath seemed to lose his Force, and to waxe weake and Dull. I iudge the cause is not by reason of the farre distance from the North-Pole, but rather by being long absent from the Stone: for not being touched or refreshed therewith. And againe, the Pinne that beareth the Flye, may be so dulled with long vsing, that the Flye is as it were stayed, that it cannot play as it would, if it were sharpe.

Therefore, if you make it sharpe with a whet-stone, you shall finde it Remedied. And also when you finde it light, or too Wickle, you may dull the poynt of the Pinne, with the lease of payre of Wyting-Tables, untill you may see the toppes thereof: and then the Compasse will be better

The new Attractum.

better for a high-Sea. And thus by sharpening and bul-
ling of the Pinne, you may make your Com-
passe fitte for all Weathers.



HERE AFTER FOLLOWETH
a Table of the Sunnes Declination, com-
monly called, A Regiment for the Sunne:
Exactly Calculated vnto the Minute, by the true place of
the Sunne: whose greatest Declination for this
Age, is 23. Degrees, 28. Minutes, and
may serue for thirtie yeares,
without great
errour.



125
1450
6/1650
27-3

^A
DISCOVERSE
OF THE VARIATI-
ON OF THE COM-
passe, or Magneti-
call Needle.

WHEREIN IS MA-
thematically shewed, the
manner of the Obseruation,
Effects, and Applica-
tion thereof:

Made by W. B.

And is to be annexed to the *Newe*
Attraction, of R. N.



LONDON,
Printed by Tho. C. for Iohn
Tappe, dwelling at *Saint Mag-
nus Corner*. 1614.



TO THE TRAVELLERS, SEA-
Men, and Marriners of England



Auing of late (*Gentle-Reader*) received from the Expert Artificer, *Robert Norman*, his Booke entituled, *The new Attraction*: (who of the great good will and affection hee beareth, hath attributed in his Dedication, that which I acknowledge not to bee due,) in the

which, amongst other diuers Vertues and Properties of the *Magnes*, or *Loadestone*: he entreateth of the *Declining* of the *Needle* touched therewith, from the plaine of the *Horizon*: (a matter neuer before found, or written of by any.) For the further behoue and benefite of all Trauelers and Sea-men. I tooke occasion to enlarge the same, with this discourse of the *Variation* of the *Compass*, wherein I haue handled the whole varietie of that subiect, both practically, and Mathematically; to the end I might partly satisfie both the vulgar, and also the Learned sort. For knowing the *Variation* of the *Compass*, to be the cause of many errors and imperfections in *Nauigation*: and perceiving that all those that haue as yet gone about to giue rules in that Arte, haue left this (being a principall point, and euen the ground of all the rest) vntouched, or at least so sleightly handled the same, that little or no benefite could be gathered thereby: I haue heere set downe the sundry wayes to obserue the same at all times and places, that the inconueniences being knowne, might be considered of, and auoyded.

Wherein, although my chiefeſt intent hath bene to pleasure those that shall haue occasion to put the thing in practise by their owne Trauell and Experience: yet because some of the rules are deducted from the fountains of the Mathematicall sciences, and wrought by the doctrine

of

The Preface.

of Signes and Triangles, which may seeme strange in our *English-Tongue*: and wherewith fewe Sea-men are yet acquainted, I may seeme to haue mist of my first good meaning; But I would wish them to chuse that which is plaine & conformable to their capacities, and make theyr profit thereof, and for the rest vnderstand, that of such obseruations as they themselves cannot presently applie to the purpose, by others, that are thoroughly instructed in these Mathematical supputations, or by themselves when they shall attaine to the knowledge therof, may be inferred such effectuall matter, as is by these rules & precepts promised. Wherefore I would haue all Sea-men to vse such diligence in their Trauells, that no opportunity be omitted, when, or where any obseruation may be made, either for the *Variation*, or *Latitude* of places, or any other necessary point incident to Nauigation, and thereof continuall notes and memoriall. For these obseruations, there needeth not many troublesome instruments, only for the *Variation*, the new instrument in the end of this Treatise, I preferre before all other. And for *Elevations*, a plaine *Astro-labe*, exactly made, and a *Crosse-staffe*, are sufficient. (The *Globe* were also a very good and necessary instrument: for besides many pleasant Conclusions that may be try'd by it, it doth lighten very much the conceits: for vnderstanding diuers important points, but it is too troublesome (or otherwise not fit for euery Marriner) to be carryed to the Sea. Vnto the which may be added the *Topographycall* instrument, for taking of distances, and making descriptions vpon the Land. With these instruments, and the Sayling Compass and Marine-plate, (which are alwayes to be vnderstood the principall, & most necessarie instruments for Nauigation, for by them only, any Voyage may be made, but without them, no Nauigation can be performed:) the whole world may be trauelled, discovered, and described.

These are sufficient for a perfect Mariner, and more then these were superfluous: only *g*ruining-glasses, leads, lines, and

The Preface.

And such like Appendances of others excepted.

10 But to have all these instruments, and not to understand the grounds how to use them, were a great vanitie. Therefore I wish all Seamen and Travellers, that desire to be skilful in their profession, first to seek knowledge in *Astronomie* and *Geometrie*, which are the grounds of all Sciences and certain Arts; of the which there is written in our *English tongue*, sufficient for an industrious and willing minde to attain to great perfection: whereby he may not onely understand Instruments, Rules, and precepts, given by others, but also be able to correct them, and to devise new of himselfe. And this not onely in *Navigation*, but in *Mechanicall sciences*. As by the studious practise and exercise in these Arts, have attained to rare & singular knowlede: *Indr Vitruvius*, the *Romane*, in painting that famous *German*, *Albentus Durerus*: & in building of ships, *Marbion Baker*, our Countrey-man; and others in other faculties, as they have bin skilfull herein, so have they excelled. Having these helps and grounds, with the instruments before specified, a Mariner may be able to make description in Plat of the Coasts and Countreys, and of the Banks, Rocks, and Sholdes, in the Sea, with the Depths, and other necessary notes, observed in his owne Travells, particularly, & effectually, according to the truth (which is the chiefest part required in a perfect Mariner.) And not be alwayes tyed to the reports of other, or to the *Portugale*, or *Spanish-Marine-Plats*: which are made by the Card-makers of those Countreys, men that are no Travellers themselves, but doe all things therein, by information, and vpon the credite of others, which only commit to memorie the forme and manner of the Sea-coasts, with making some few notes of the lying of one place from another; which can never be so perfect, as the Descriptions that are made vpon the present sight and viewe of places, albeit he be never so skilfull and cunning, that shall so carry the same by memorie; how much lesse then by the vnskilfull,

The Preface.

skilfull, by this meanes the Card-makers set downe they knowe not whar, as may appeare by the Descriptions of their owne Coasts, which are very grossly and vnperfectly done: wheras the *Marin-Plats* ought to be described by such as can giue reason, and shewe obseruation of euery particularity contained in the same, aswell for the *Latitude* of places, as the lying by the Compas of the Capes, Headlands, Points, Ilands, Bayes, Rocks, Sholds, &c: one from an other, and the distances betweene them. The errors of those Descriptions, I may not attribute to the Card-makers, but to the vnskilful Sea-men of those countreys: For if they were otherwise, as they haue bene accounted, the most skilful of the world, those errors could not haue continued as they doe: true it is, that for their great Trauells, they haue bene worthily famous aboue all other Nations, till now at length our Countrey-man, Syr *Francis Drake*, for valorous attempt, prudent proceedings, and fortunate performing his voyage about the World, is not onely become equall to any of them that liue, but in fame farre surmounteth the all. But those Card-makers, & all other that collect & gather *Hydrographieall* and *Geographicall* Descriptions of other mens Trauells or Reportes: as their paines may be great, and deserue due comendations, so their doings may bring commodity diuersly. And in this behalfe, *Abrahamus Ortelius* in his *Theatrum*, hath deserued immortal praise, for collecting together, and reducing into one commodious volume, the diuerse Plats and descriptions, made by diuers and sundrye men. But amongst all those that haue made *Geographicall* descriptions, I cannot a little maruell at *Guillielmus Postellus*, who being a famous learned man, a great Traueller and *Cosmographer*; and Deane of the Kings professors in the Vniuersity of *Paris*, in his *vniversall Mappe*, Anno 1580. besides that, it is generally handled after such a grosse and confused manner, that it might seeme rather to haue come from some rude vnskilful, then from him so famous a Doctour, hath also in the imagined

Caun.

The preface.

Counteyes about the *North-Pole*, so corrupted it with his fond dreames, and fantastickall Inscriptions, attributing to those supposed Lands, diuers people, as the *Georgians*, and *Hyperboreans*, and assigning there to be the highest hills of the worlde, and the people dwelling on them, to haue the continuall light of the Sunne, *Sueta, Zemlia*, found by the *Englishmen*, *Ann.* 1550. the holy Land, the place of the chiefe felicity, the *Hyperborean* fields, and therefore the felicity of the *Moluccas*, with many other ridiculous absurdities: that by the grosse errors of this learned man in these matters, I am taught, that whatsoever Fame goeth, or opinion is conceiued of any man for profound learning, and smooth deliuering of their conceits, or whatsoever great promises are by themselues made in these Arts, to iudge of them according to the workes that come from them, and not otherwise to beceiued.

For auoyding prolixitie in this my Preface to so small a volume, I referre thee gentle Reader, to the worke it selfe. Yet by the way, it shall not be amisse, that I commend vnto you the Table of the Sunnes declination (or Regiment) made by *R. N.* which is Calculated for the present time, and differeth not from the truth in any place, aboue one minute, whereas in all other hitherto made and extant, there are great errors. Therefore, such as otherwise cannot from time to time calculate their declinations, according to the place of the Sunne to be giuen by the *Ephemerides*, and Table of Declination of *Reinboldus*, may boldly vse this Regiment for 20. yeares, without any sensible error. And so wishing my Trauells in this Treatise, may doe such good as I meant, I commit the same to your gentle constructions, and your selues to the Almighty. At *Lincolne*, the 26. of September. Anno 1581.

William Bourrough.

OF THE VARIATION OF the Compasse, or Magne- ticall Needle.

CHAP. I.



THE Variation of the Needle or Compasse, is properly the Arch of the Horizon, contained betwene the true Meridian of any place, and the Magneticall Meridian of the same: and is denominated to be Easterly, or Westerly, according to the position of the Magneticall Meridian, to the Eastwards or Westwards of the true Meridian: and may be accounted either from the North parte, or the South parte thereof: But vpon Opposite poyntes, it hath contrarie Denominations.

The Magneticall Meridian, is to be understood a great circle passing by the Zenith and the Pole of the Magnes, deviding the Horizon into two equall parts crossing the same at opposite points: which interseptions or crossings, are shewed by the needle, or wires of the Compas, touched with the Magnes, or the Loade-stone.

The Azimuth of the Sunne is a great Circle, passing by the Zenith, and the true place of the Sunne: crossing the Horizon at right Angles, in Opposite poyns, and diuiding the same into two equall partes, and it is saide to be given, when the distance thereof, from the true Meridian is knowne.

The Azimuth of the Sunne vpon equall Eleuations in Forenone or Afternone, hauing equall distances from the true Meridian: So that the middle point of the whole difference of any two Azimuths, obserued vpon equal Eleuations, in Forenone or Afternone, is the true Meridian.

This difference of Azimuths, is found vpon the Instru-

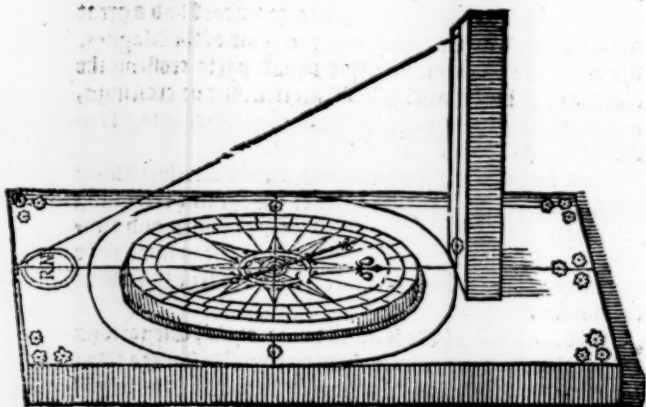
Of the Variation

ment of Variation, by adding together the Variations of the suns shadowe, at equal eleuations in the forenoone and afternoone. The halfe whereof is the distaunce of the Azimuths from the true Meridian: the which compared with either of the same Variations of the sunnes shadow, the difference shall be the Variation of the neede, from the true Meridian.

Or els subtracting the lesser variation of the Sunnes shadowe, from the greater (at equall eleuations) the halfe of the remainer shall be the true Variation of the Neede from the Meridian.

But the Azimuth of the Sunne being otherwise given, and the Variation of the shadow likewise given, the difference betweene them, is the variation of the neede.

The Variation of the Sunnes shadow, I call the Horizontall distaunce betweene the Azimuth of the Sunne, and the Magneticall circle, which are represented in the Instrument, by the shadowe of the line, and the neede.



Of the Compasse.

CHAP. II.

The manner how to vse the instrument
of Variation.



First you must place the instrument vpon some stole, or other thing that is flat, so as it may stand leuell, and the Plummet in the Standard, which is placed at the South end of the fixed flie may fall perpendicularly, with the line in the same Standard. You must haue regard that in remouing the instrument to the sunne as he goeth about, it may alwayes stand leuel as aforesaid.

You are then to consider, that the string that reacheth from the south parte of the Instrument to the top of the standard, is the chiefest string to giue the sunnes shadow, which must be so directed by turning the Instrumentes South side to the Sunne towards, that the shadowe of the same may fall directly longest vpon the line of south and North in the fixed flie, for it ought not to crosse or decline from the same line in any part, but if it do, you must seeke to refozme it, by setting the standard more vpright, or remouing it at the south end.

Then must you also see, that the string that is fastned to the hope of Basse that inuironeth the fixed flie, may be so placed that it agree iustly with the shadowe of the former line, and the line of south and North in the fixed flie, in such sort that both the shadowes may be as it were hidden in the said line of the flie: which you may do aptly by turning the said hope, and remouing the same line at either side of it, as you shall see cause.

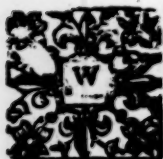
The Instrument being duly placed in forme aforesaid, it differs nothing from the Compasse of Variation, but onely in this point, that whereas the flie of the compasse of Variation, is so turned by vertue of the Magnetical wiers

Of the Variation

twiers, that the North point thereof both shew the Pole of the Pagas, or line of Variation. In this Instrument, the North point of the Needle doeth supplie that, which the North point of the compasse should doo. And the North point of the stile which is fixed in the bottome of the Instrument, doth alwaies aunswere to the shadowe that the Sunne giueth.

CHAP. III.

How to finde the variation of the Needle or Compas at any place, the eleuation of the Pole, and scituation of the Meridian vnknowne.



When you would obserue the variation in any place, you must begin in the forenoon the sooner the better, and the more effectually may your obseruations bee, doe thus: Take your Astrolabe, and obserue directly the height of the Sunne, for your more ease it shall be best for you to note the same, when it agreeth to be iust vpon a degree, without any consideration of minuts, or fractions, and at the instant of the same height, turne your instrument to the Sunne, so as the shadowe of the lines may fall iustly vpon the line of the south and north in the fixed stile.

Then, when the Needle doth stand, looke directly ouer the North point of the Needle, what degree and fraction, (if there be any) doth answer vnto y same in the fixed stile, that is to say, how many degrees it is from the North of the fixed stile, which you shall note diligently, and may say, that so many degrees, &c. is the variation of the Sunnes shadow from the North, as the North point of the stile is from the North point of the Needle, either Eastwards or Westwards as you shall finde the same. Thus may you obserue diuers times, vpon severall degrees of the Sunnes Eleuation.

Of the Variation

Elevation. And like as you do in the forenoone, so must you also obserue the Sunnes elevation in the afternoone vpon the same degree of height, and with the same Re of the A. Crolobe and Index turned towards the sunne, as it was in the forenoone (so; auoiding of errour that may be in the Instrument) noting at euery height, what you finde the Variation. And when the Sunne commeth to the Meridian, it shall be good that you exactly obserue his Elevation vpon the same, so; knowing the true Latitude of the place: All which you shall set downe in forme following.

Example.

In *Lime-house*, the sixteenth of *October*, Anno. 1580.

Forenoone.			Afternoone.		
Elevation of the Sunne.	Variation of the shadowe from the North of the Needle to the Westwards.	Elevation of the Sunne.	Variation of the shadowe from the North of the Needle to the Eastwards.	Variation of the Needle from the Pole or Axes.	
Deg:	Deg: Min:	Deg:	D: M:	D: M:	
17	52 35	87	30 0	11 17 $\frac{1}{2}$	
18	50 8	18	27 45	11 11 $\frac{1}{2}$	
19	47 30	19	24 30	11 30	
20	45 0	20	22 15	11 22 $\frac{1}{2}$	
21	42 15	21	19 30	11 22 $\frac{1}{2}$	
22	38 0	22	15 30	11 15 $\frac{1}{2}$	
23	34 40	23	12 0	11 20	
24	29 35	24	7 0	11 17	
25	22 20	25	frō N. to w. 0.8.	11 14	

The

Of the Variation

The eleuation or the Sunne vpon the Meridian. 25. d. 58 min. the declination 12. d. 30 min. which I adde to the eleuation, because the Sunne hath south declination, and therof amounteth 38. d. 28 min. the eleuation of the equinoctiall, the which I substract from 90. d. the rest is 51. d. 32 min. the eleuation of the Pole Artike.

Now are you to consider, that out of the greates Variation of a shadowe vppon any degre of the sunnes eleuation, is to be taken the lesser of the same degrees eleuation, whether it be in the forenoone or afternoone (except the same variations be both one way from the North of the Needle, which then are to be added) the halfe of the remainder, is the variation of the Needle, or Compass, from the Pole or true Meridian.

In the former obseruations, I do finde the greatest variation in the forenoone, for at 17. d. eleuation, the variation is 52. d. 35 min. from North to West: And at the same eleuation in the afternoone, I finde the variation to be but 30. d. 0. min. from North to East. I take the lesser out of the greater, & finde remaining 22. d. 35 min. the halfe thereof is 11. d. 17 min. one sec. So must I say to the pole Articke, and true Meridian line that passeth to the pole, by our Zenith at London, to the Westwards of the North that the Needle sheweth. And therefore the Needle or Compass varieth from the true north, 11. d. 17. min. one sec. to the eastwardes: Also at 25. d. eleuation in the forenoone, the variation is 22. d. 20. min. from North to west, at the eleuation in the afternoone, the variation is. 0. d. 8. min. from North to west. Now because the variations are both one way that is to the westwardes) I adde them together (and so ought you to doe, as often as you finde the variations so to agree) & I finde that they amount to 22. d. 28. min. the halfe thereof is 11. d. 14. min. which is the variation.

The variations of the Needle or compass by the former obseruations, are set out to wardes the right hande against every degres eleuation, and conferring them altogether,

Of the Compasse.

I do finde the true variation of the Needle of Compas at Limehouse, to be about 11. d. one qu: or 11. d. one thirde: which is a point of the Compasse iust or little more. So that in a Compas whose wires are set directly vnder the flowre de Luce, the north, and by West, and South and East pointes doe shew the true Meridian.

CHAP. IIII.

The eleuation of the Pole, and place of the Sunne, giuen, how vpon the Globe, to find the variation of the Needle by any one obseruation, either in forenoone or afternoone.

IF the former declaration, the onely way to trie the variation, is by comparing of the severall correspondent obseruations of the Sunnes eleuation in the forenoone, with those of the afternoone, so that if the Sunne should be obscured, or by any other occasion like obseruation cannot be made in the afternoone, then the former rule giueth not the desired purpose. Therefore I thought good to shew, how by any one obseruation in the fore or afternoone, the eleuation of the Pole and place, of the Sunne giuen, you may knowe the true Meridian and the variation of the needle from the same in any place, which thing may be done and aptly demonstrated vpon the Globe, but most exactly calculated by the Table of sines.

To finde out the variation vpon the Globe, you must first set your Globe to stand duely according to the eleuation of the Pole at the place proposed. Then take in the Ephemerides, for the true place of the Sun that day, and note it with some small prick in the Cliptick of the globe: And placing the Quadrant of altitude or moueable verticall, at the verticall point or Zenith, take the eleuation
of

Of the Variation

of the Sunne, observed by the Astrolabe or other Instrument at the time proposed; and note it iustly vpon the same Quadrant of altitude. Then turne your Globe and Quadrant towards that part of the Horizon that the sun was in at the time of the obseruation, till the pꝛicke you made for the place of the sunne in the Eclipticke, concurre and agree iustly with the eleuation marked in the saide Quadrant of altitude: so shall you see the Quadrant shew you vpon the Horizon, the Azimuth and distance of the sunne from the true Meridian of that place, which you shall compare with the variation obserued vpon the Instrument at that instante of the sunnes eleuation. And if they agree and concurre iust, then shall you be in the true and common Meridian, which sheweth the Pole of the world, and Pole of the Magnes or Loadstone. But if they differ, you shall subtract the lesser from the greater, the remainder sheweth the Variation. And if the variation vpon the Instrument be greater then the true distance of the Azimuth from the Meridian found vpon the globe, the same surplus is to be accounted for variation: vpon the contrary side of the Meridian: if it be lesse, it is to be accounted on the same side of the Meridian that the variation is taken, whether it be in the forenone or afternone. This precept needeth no further demonstration, then the instrument it selfe, the Globe I meane.

But for example of the worke, I take the first obseruation, in the former Chapter specified, made at Limehouse, the sixteenth of October. 1580. in the forenone, which is 17. d. eleuation & variation, 52. d. 35. min. from North to West.

First I set my Globe at 51. d. 32. min. for the eleuation of the Pole. Secondly, I take the place of the Sun 2. d. 55. of scorpio, & note it vpon the Eclipticke. Thirdly, I note vpon the Quadrant of altitude, the eleuation of the Sunne. 17. d. This done, I moue the quadrant of altitude towards the East of the Horizon, and turne the Globe till the pꝛicke in the

the

Of the Compasse.

the Ellipticke for the place of the Sunne, do agree in this, with the eleuation noted vpon the quadrant of altitude, & find the true azimuth thereof by the same quadrant vpon the Horizon to be nextest, about 41. 1. third from the Meridian; and consering the same with the variation found vpon the Instrument. 52. d. 32. min. I finde the difference 11 d. 15. min. and because the obseruation is noted to be in the forenoone from the North to the West, or South to the East, and the variation vpon the Instrument greater then the azimuth found on the Globe. I account the same from the North to the East, or from the South to the West. So I conclude the variation at Limehouse to be about 11. 1. quarterne, from North to East, or South to West.

CHAP. V.

How to find the Variation by Arithmetical calculation vpon any one obseruation in the forenoone or afternoone, the latitude of the place, and declination of the Sunne being given.



The summe of the worke is to finde the arche of the Horizon betwene the meridian and the azimuth of the sunne at the time of the obseruation, which being compared with the variation found in the Instrument, the difference is the Variation of the Needle. For attaining of the same arche: first it is necessarie to haue the arche of the Equinoctiall betwene the sunne at the time of the obseruation, and the meridian, which arche is thus found.

Multiply the sine of the Sunnes Meridian altitude for the day proposed by the whole sine, the product diuide by the sine of the eleuation of the Equinoctiall (or the complement of the altitude) the quotient is the versed sine or half of the Semidiurnall arche, which you shall note

Of the Variation

note for the first number.

Then againe multiply the sine of the Sunnes Eleuation at the time of the Observation, by the whole sine, and the Producte, deuide by the sine of the eleuation of the Equinoctiall, the Quotient subtract from the number you first noted, the rest is the versed sine of the Arch, of the distance betwene the Sunne and the Meridian in the Paralell that it is in for the time proposed, in such parts as the Semidiameter of the Equinoctiall is the whole sine: but it is necessary before you applie it any further, to reduce it into such partes as the Semidiameter of the paralell is the whole sine, which you may doe thus: Multiplie this remainder by the whole sine, the product deuide by the sine of the complement of the Declination (which is the Semidiameter of the paralell) the Quotient is the versed sine, in his proportionall partes.

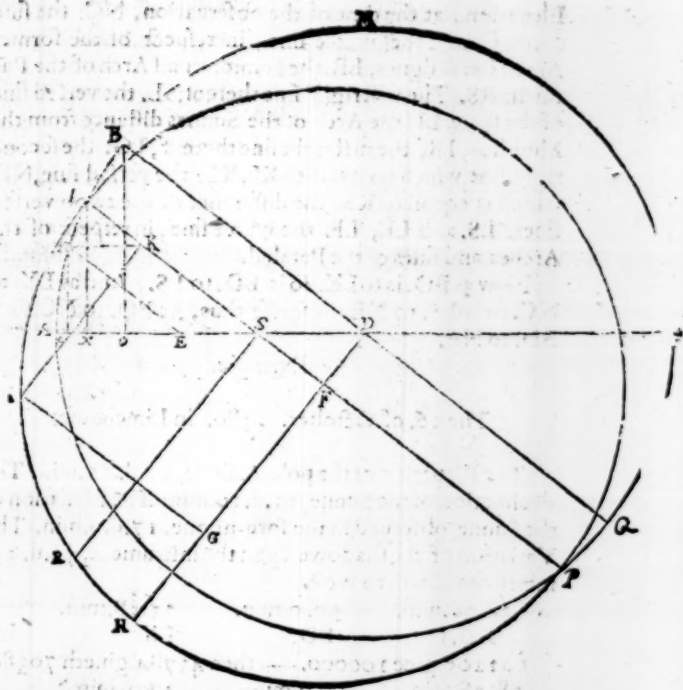
This versed Sine thus reduced and subtracted from the whole sine, leaueth the second right sine, which you shall seek in the Tables of Sines, and thereby finding his Arch, you shall subtract the same from the Quadrant, or 90. d. the remainder is the arch of the foresaid paralell of the Sunne, which is answerable or correspondent in degrees and minutes, to the arch of the Equinoctiall, that you seek. The reason of the precept is this.

As the right sine of the eleuation of the Equinoctiall, is in proportion to the right sine of the Meridian altitude of the Sunne or any Starre: so is the whole sine, to the versed sine of the semidiurnall arch. And againe, as the right sine of the Meridian altitude, is to the right sine of the Eleuation of the sunne or starre, at the time of the obseruation, so is the versed sine of the semidiurnall arch of the same, to the excessse or difference betwene the same versed sine and the versed sine of the distance from the Meridian.

For the better understanding of the premises, I haue set downe this Figure following, and wish the Reader to consider of the same, with the 4. Pro. of the 6. of Euclide.

Let

Of the Compass:



L Et AMT, be the right Meridian Circle, BDQ, the common section of the Meridian, and Equinoctiall theyr Plaine, which is also the Diameter of both Circles.

AET. the plaine of the Horizon, LHP, the paralll of the Sun, which is described vpon the Center F. at the distance FL. which is the sine of the complement of the declination. AB. the arch of the eleuation of the Equinoctiall BO. the first right signe thereof, AL. the arch of the Meridian altitude. LX. the sine thereof, AN. the arch of the Sunnes eleua-

of the Compass.

Elevation, at the time of the obseruation, NC. the fine thereof, BD. the whole fine, in respect of the former Arches and signes, LR. the Semidiurnall Arch of the Paralell. RS. The first right fine thereof, SL. the versed fine of the same, LI. the Arch of the Sunnes distance from the Meridian, IK. the first right fine there. f, IG. the second right fine which is equall to KF. KL. the versed fine, NE. which is equall to KS. the difference of the twoo versed fines. LS. and LK, LF. the whole fine, in respect of the Arches and fines of the Paralell.

Now as BO. is to LX. so is BD. to LS. And as LX. to NC. so is LS. to NE. Or else thus, As BO. to NC. so is BD. to NE.

Example.

The 16. of October. 1580. in Limehouse.

The Elevation of the pole Articke, 51. d. 32. min. The declination of the Sunne, 12. d. 30. min: The Elevation of the Sunne, obserued in the fore-noone. 17. d. 0. min. The Variation of the shadowe vpon the instrument, 52. d. 35. min: from North to west.

38.28.min.	90.0.min.	25.58.min.	
BO.	BD.	LX	LS.

If 62205. giue 100000. — then 43784. giueth 70386.

38.28.min.	90.0.min.	17.0. min.	
BO.	BD.	NC.	NE.

Against, if 62205. giue 100000. 2937. shall giue 47001.

Now out of LS. — 70386.
Take NE — 47001.
Rem. LK. — 23385.

Then if LF. 97629. the fine of 77. d. 30. m. the complement of the declination, giue LF. 100000. then IK. 13385. giueth IK. 23952. the versed fine of the Arch: IL. is his due

of the Compasse

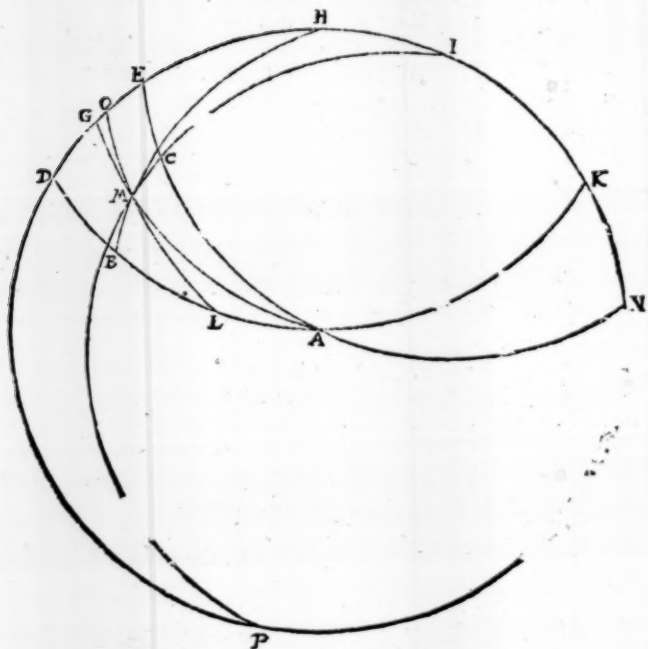
due partes, the same subtracted from L. F. 100000, the whole line, leaueth KF. or IG 7604. the second right sine of the same Arch, which is the right sine of the Arch. IH. which Arch you shall find in the Table of sines to be 49. d. 10. min. 24. sec. The complement whereof to the Quadrant is 40. d. 29. mi. 36. sec. the Arch IL. of the parallell between the Sun & the Meridian, whose correspondent Arch in the Equinoctiall, is the Arch that was sought.

Now hauing this Arch of the Equinoctiall, you must worke as followeth.

Multiply the sine thereof, by the sine of the complement of the Declination, and diuide the Product by the whole sine: the Quotient is the sine of an Arch, contained betwene the Sunne and the Meridian, making right angles with the Meridian. This sine multiplie by the whole sine; the Product diuide by the sine of the complement of the Sunnes elevation, at the time of the obseruation: the Quotient shalbe the sine of the arch of the Horizon, contained betwene the Azimuth of the Sunne and the Meridian, which is the Arch that was proposed to be found.

L Et DHNP. bee the Meridian, DAK. the Horizon, EAN. the Equinoctiall. M. the place of the Sun in the heauen, at the time of the obseruation. LMO. the Parallell. HMB. the Azimuth, or verticall Circle passing by the Sunne. AMG. a great Circle imagined to passe by the Sunne, and to crosse the Meridian at right angles. IMP. a great circle passing by the Poles of the world. & place of the Sunne, at the time of the Obseruation, commonly called the circle of hours, or circle of declination. CM. the suth declination of the Sunne. MP. the complement thereof to the Quadrant. MG. the Arch between the Sunne and the Meridian of the former imagined circle. AMCMO. the Arch of the Sunnes parallell. EC. the correspondent Arch of the Equinoctiall, which are giuen in the former worke. MB. the elevation of the sunne, at the time of the obseruation.

Of the Variation



tion. MH. the Complement thereof, BD. the Arche of the Horizon, intercepted betweene the Azimuth, and the Meridian, which is the thing required to be found.

In this Figure the Reader is to consider the manner of the Sphericall triangles, and to compare the lines of the sides, according to the doctrine of Copernicus, in the 14. Chapter of his first Booke, and of Regiomontanus, his 25. and 27. Propositions, of his 4. Booke of triangles.

As PC. is to CE. so is PM. to MG. but three of them are

of the Compasse.

are giuen, therefore the fourth shall be knowne.

And as HM. is to MG. so is HB. to BD. the Arch that is sought, which by three first giuen is likewise giuen.

¶ The second part of the Example.

90. 0. m.	40. 29. m;	36. sec:	77. 30. m:
PC.	EC.	PM.	MG.

If 100000. giue 64935. — then 97629. giueth 63395.

37. 0. m:	90. 0. m:	41. 31. m. 22. sec:
HM.	MG.	HB. BD.

Againe, if 95630. giue 63395. — 100000. giueth 66291.

Whose Arch BD. 41. d. 31. m: 22. m: is the Horizontall distance of the Azimuth of the Sunne, from the Meridian, the thing that was sought.

Now comparing the same with the Variation found vpon the Instrument, at the instant of 17. D. Elevation, which is 52. d. 35. min: I finde it to be lesse, and therefore subtract it, and so haue I the difference, 11. d. 3. min: 38. sec: And because the Observation was in the forenoone, & the Variation vpon the Instrument, greater then the Arch of the Horizon, betwene the Sunnes Azimuth, and the Meridian: therefore I conclude, that the Variation is 11. d. 3. m: 38. sec: from South to West, or north to East, which is the thing promised to be shewed.

But comparing the same arch of the Horizon, 41. d. 31. m: 22. sec: with the Variation found at the correspondent Elevation in the afternoone: which is 30. 0. m: I subtracte the lesser from the greater, and finde the excess, 11. d. 1. m: 22. m: which should be the Variation. And because the Variation found vpon the Instrument, is lesse then the arch of the azimuth vpon the Horizon, I account the Variation on the same side of the Meridian, which is, from South to West, or north to East.

This variatie betwene the Observation made in the

Of the Variation

fozennone, and that in the afternone, proceedeth eyther of the imperfection of the instrument, or negligence of the observer. For in the Rule there can be no error, being grounded vpon Geometricall demonstration, then which, nothing can be more certaine.

The former precepts and examples doe serue when the Sunne doth decline from the Equinoctiall, eyther northwards, or southwards. But if the Sunne be in the Equinoctiall, then the manner of the working is more easie and briefe. For if you multiplie the sine of the Sunnes elevation, at the time of the obseruation, by the whole sine, and denide the Product by the sine of the elevation of the Equinoctiall, which is the Peridia altitude, the Quotient giueth the second right sine of the distance of the Sunne from the Meridian, which is the first right sine of the complement of the same Arch: and entring the Table of sines with it, you shall finde his Arch: which if you subtract from the Quadrant, or 90. D. leaueth the arch of the distance of the Sunne from the Meridian. And hauing the same, worke thus. If the sine of the complement of the elevation of the Sunne, at the time of the obseruation, giue the sine of the foresaide Arch of distance; What shall the whole sine giue? Multiplie and denide, the Quotient shall be the sine of the arch of the Horizon, contayned betwene the Azimuth of the Sunne and the meridian. Which arch being compared with the Variation of the instrument, in manner as before is shewed, giueth the Variation required.

But the Sunne being in the Equinoctiall, if the place where the Obseruation is made, bee likewise vnder the same circle, then is the Variation most easily obserued: for that the equinoctiall is the azimuth of East and West: Wherefore turning your instrument onely to receiue the shadowe of the Sunne, and looking then to the north point of the stile; if you finde the same to answer to the Quadrant, or 90. D. you shall be in the Meridian of the Magnes, which passeth by the Poles of the worlde, but if it

doe

of the Compasse.

Doe differ from 90. D. the same difference is the Variation of the needle.

But admitting the Observer to be under the Equinoctiall, and the Sunne to haue Declination: then the proportion of the sine of the complement of the Elevation, at the time of the Observation, vnto the sine of the Declination shall be such, as the whole sine is to the sine of the arch of the Horizon, included betwixt the Azimuth of East and West, which is the Equinoctiall it selfe, and the Azimuth of the Sunne for the time of the Observation, the complement whereof giueth the true Meridian: which complement you may compare with the Variation shewed vpon the Instrument, the Difference is the Variation.

Diuers other cases might be proposed, and rules giuen for them, which for breuitie I omit.

But one thing I thought good to admonish you by the way, that whereto I haue shewed in the first parte of this Proposition, the manner to finde the two Versed Sines: the one of the Semidiurnall Arch, the other of the arch of the distance of the Sunne from the Meridian. By the first, the Semidiurnall arch being found, and reduced into houres and minutes of time, is shewed the last halfe quantity of the Day. And by the Arch of the other likewise reduced, the houre of the Day, or the time containned betwixt the nonecke, and the instant of the Observation: as in the same example.

The Versed sine of the Semidiurnall arch, LS. is giuen 70385. in such parts as the semidiameter of the Equinoctiall BD. is 100000. therefore I reduce the same into such parts as the semidiameter of the paralell, LF. is 100000. and finde it to bee 72095: Which subtracted from the whole sine, LF. 100000. there resteth, SF. 27905. which is the second right sine of the semidiurnall Arch LR. and the right sine of RH. 16. d: 12. min: which is the complement of the Semidiurnall Arch LR. wherefore subtracting it from the Quadrant, LH. 90. d: resteth 73. d: 48. mi:

Of the Variation

the Semidiurnall arch LR the same reduced into partes of time, allowing 15.d. for a houre 15.m. for a minute, and 15. sec. for a second of time, and for every degree 4. minutes of time, for every minute 4. sec. & for every second 4. thirds. &c. 31 finde the time of that arch from the time ascendent, to the Peridian, which is halfe the day, to be 4. houres 55. m. 12. sec. and consequently the whole day, being the 16. of Dec: tober above written, to be 9. houres 50. m. 24. sec. long.

This example may serue for a generall precedent, whiles the equinoctiall is betwene the sunne and the eleuated Pole, but if the sunne be betwene the eleuated Pole, and the Equinoctiall, then will the versed sine fall out to bee greater then the whole sine, and the semidiurnall arch to excede a Quadrant. Wherefore hauing reduced the same into his proportionall parts, as before is shewed: subtract from it the whole sine, the surplus is the sine of the exesse of the Semidiurnall arch above a Quadrant, which being added to the Quadrant, giueth the semidiurnall arch.

By the other versed sine of the distance of the sunne from the Peridian, which is LK. 23952. in such partes as the whole sine or Semidiameter LF is 100000. subtracted from the whole sine, is giuen KF. 76048. the second right sine of the same arch of distance, and the first right sine of 49.d. 30.m. 24. sec. which is the complement of the arch of the Sunnes distance from the Peridian: therefore subtracting the same from 90.d. resteth 40.d. 29. m. 36. sec. the arch of the distance betwene the sunne and the Peridian, which being reduced into partes of time as before, giueth 2. houres 41. m. 52. sec. and the same (because it is in the forenone) deducted from 12. houres the noneford, resteth 9. houres 18. m. 2. sec. the last instant of the time of the day.

But if this versed sine be found to be greater then the whole sine (as it may when the sunne is betwene the Equinoctiall and the eleuated Pole, and before the houre

of the Compasse.

or fire in the morning, and after the houre of fire in the evening) then both the arch of distance consequently exceede a Quadrant, the sine of this excesse is the surplus of the versed sine about the whole sine. Whose arch added to the Quadrant, giueth the arch of the sunnes distance from the Meridian, and reducing the same into partes of time, is giuen the instant of time of the obseruation.

As by this meanes (the eleuation of the sunne beeing precisely obserued and latitude knowne) the instant of time of the day is giuen more exactly, then by any Clocke, Diall, or other Instrument. So if there might be had a portable Clocke that would continue true the space of 40. or 50. houres together (if longer time the better) then might the difference of longitude of any two places of knowne Latitudes, which conueniently may bee traualled within that time, be also most exactly giuen. And in this sort traueilling and obseruing from place to place, might the Longitudes of any Countrey be perfectly described.

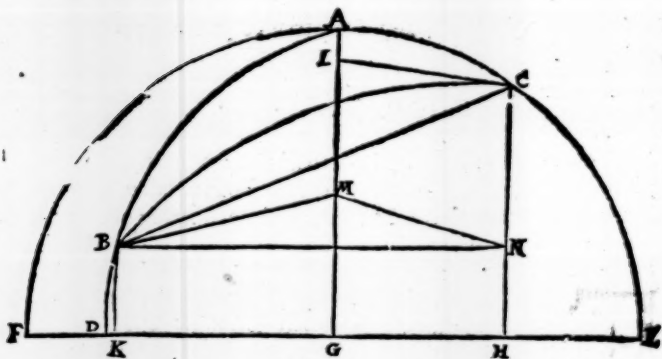
CHAP. VI.

Another way most generall, how to finde the Variation by one obseruation, either in the forenoone or afternoone, the eleuation of the Pole, and declination of the sunne being giuen.

For the accomplishing of this proposition, you are to imagine a sphericall Triangle vpon the superficies of the Globe, whose sides must be. First, the portion or arch of the Meridian betwene your Zenith and the Pole, which is the complement of the latitude. The second, the arch of the verticall circle contained betwene your Zenith and the sunne, which is the complement of the sunnes Eleuation at the time of the obseruation. The

Of the Variation

The third side is an arch of the circle of declination, comprehended betwene the sunne and the elevated Pole, this arch is found by adding, or subtracting the declination of the sunne, to or from, the Quadrant or 90. which must be done with this consideration, that if you be on the same side of the Equinoctiall that the sunne is, you are to subtract the declination from the Quadrant. If on the other side, to ad it to the same, so haue you the thre sides of the sphericall triangle giuen. When the substance of the worke consisteth in finding the quantitie of the angle of the same triangle at the Zenith, for the complement thereof to the Semicircle or two right Angles, is the Horizontall distance of the Sunnes Azimuth, from the Meridian, which being compared with the variation of the Suns shadowe vpon the Instrument, giueth the thing required.



L Et FACE, be the Meridian, wherein A. the Zenith. C the Pole. AD. the virticall circle of Azimuth of the Sunne passing by B. the place of the Sunne at the time of the obseruation. BD. the eleuation of the Sunne. BA. The complement of the eleuation AC. the complement of the latitude. BC, the arke of the circle of declination, or the

of the Compasse.

the chord of the same arch. FGE. the plaine of the Horizon.

Now from the three angles of the triangle ABC. let fall 3. perpendicular lines to the plaine of the Horizon. AG CH. and BK. and by the 6. of the 11. of Euclide, these three lines shall be paralels.

Then let fall a perpendicular line from C. vpon AG. in the point L. from B. another perpendicular vpon the same line AG. at the point M. and from the same point M. erect a perpendicular line to N. which shall be paralel and equal to LC. Then ioyn B. and N. together. So haue you a right lined triangle. BMN. whose angle at M. is equall to the angle A. of the sphericall triangle ABC. By the 4. definition of the 11. Euclide, for the like reason is of obtuse angles as of a cuted or sharpe. And the sides thereof BM and MN. are giuen BM. the signe of BA. and MN. equall to LC. the signe of CA. And the third side BN. is found by subtracting the square of NC. from the square of the chord BC. as in the 47. of the first of Euclide.

And in the right lined triangles, the three sides beeing giuen, the angles are also giuen, by the 44. 45. &c. of the first of Regiomontanus, and by the 7. proposition of the 13. chapter of Copernicus his first booke.

For example, I take the former obseruation of
the 10. of October. 1580. and worke
as followeth.

The eleuation of the Pole CE. 51. d. 52. the sine thereof CH. 78297. The eleuation of the sunne BD. 17. d. 0. m. the sine thereof BK. 29237. The Arch BC. 102. d. 20. min. the chord thereof BC. 15970. The complement of the eleuation of the sunne BA. 72. d. c. m. the sine thereof BM. 95620. the complement of the Latitude AC. 37. d. 28. m. the sine thereof LC. 62205 equall to MN.

Now

Of the Variation

Now out of CH. 78237. Subtract NH. equall to BK.
29237. Rest, NC. 59060.

Then out of the chord BC. squared—44328; 12576.
Take the square of NC—2406883600.

Rest the square of BN.—21921628976.

The Roote thereof is 148059. the side BN.

So are the three sides of the triangle giuen $\left\{ \begin{array}{l} \text{BN. 148059} \\ \text{MN. 62205.} \\ \text{BM. 95630.} \end{array} \right.$



Now I finde the angle MI. subtract from the square of BM. the bigger side, which is 9145096900. the square of MN. the lesser side, which is 3869462025. Rest, 5275634875. which deuided by the base, BN. 148059. giueth 35631. the halfe thereof, 56214. in IN. the lesser case or shorter part of the base deuided by the perpendicular line MI. falling vpon the same, from the obtuse angle M. which subtracted from the whole base BN. 148059. leaueth IB. 91845. the greater case, or longer part thereof.

Now it is manifest, that these two cases or parts of the base, BI. and IN. are the sines of the two sharpe Angles, IMB. and NMI. made of the obtuse angle, M. by the perpendicular falling from the same Angle to the base, and the archs of them ioyned together, are the quantity of the obtuse angle, NMB.

Therefore to reduce them to the numbers of the sines, first for the greater case BI. making BM. the whole sine, say.

BM,

of the Compasse.

BM. BM. BI. BI.

If 95630. giue 100000.—then shall 91845.giue 96042.

The Arch therof is 73.d: 49.m: 38.sec: Againe for the lesser case, making MN. the whole sine, say,

MN. MN. IN. IN.

If 62205. giue 100000. —then 56214 giueth 90376.

Whose Arch is 64. d: 38. m: 45. sec: And adding these two archs together, they giue 138.d: 28.m: 23.sec: the arch or quantity of the obtuse angle, NMB. equall to the sphericall angle, BAC. and deducting it from the semicircle, 180.d: there resteth 41.d: 31.m: 37.sec: the angle, FAD. the Horizontall distance of the Sunnes Azimuth from the Meridian, and subtracting that frō 52.d: 35. the variation found vpon the instrument, frō North to West in the forenoone, resteth, 11.d: 3.m: 23.sec: the variation of the Needle from the Meridian: the thing that was proposed to be found. And comparing the same with the afternoones obseruation, you shall finde it 11.d: 31.m: 37.sec: the cause of this difference, I haue declared in the former Chapter.

If the Reader be delighted with variety of Demonstration of this matter, let him peruse the 34. Proposition of the 4. of Regiomontanus, and the 3. proposition of the 14. chapter of the first booke of Copernicus,

But whereas you see this Calculation to differ from the former in some odde seconds: The reason thereof is not as it might be taken the different nature of the Rules, but in the working thereof, omitting the fractions in the diuisions, and neglecting the proportional parts of the signes and archs.

In these examles I haue vsed the abridged Table of 100000. the whole sine, which though it giue some ease in the working, yet it is not so exact, as that of 10000000. of Erasmus Reinholdus. Vnto the which, with his Canon secundus, answerable to the same, if the third canon of the Hypo-

Of the Variation

Hypothenuſes were annexed, wee ſhould haue an entire Table for the doctrine of Triangles, that might worthily be called, The Table of Tables. Which thing, though Georgius Ioachimus Rheticus haue well begunne, and ſcamed it orderly, from ten Minutes to ten: yet is it left very rawly, for ſuch as deſire the exact truth of things. I haue therefore for mine owne eaſe and vſe, Calculated the complement of this Table, and almoſte ended it, for the whole Quadrant, from minute to minute: which if in the meane time beſore I haue finiſhed, I ſhall not finde it ex- tant by any other, I will publiſh it for the commoditie of all ſuch as ſhall haue occaſion to vſe the ſame for nauigati- on and Coſmographic.

To finde the Eleuation of the Pole, Scituation of the Meridian, and Variation of the Needle, at any place by the Sunne, vpon two Obſeruations, cy- ther in forenoone, or afternoone.

CHAP. VII.



Whereas in the thre laſt Chapters, the groundſof the Calculations conſiſt in the Eleuation of the Pole to be giuen, which thing to knowe is no leſſe difficult, then the chiefe matter that is by them requyred; for the common pre- cepts, which as yet haue chiefly bin gi- uen for the finding thereof, depend on- ly vpon the Obſeruatiſon of the Meridian altitude of the Sun or ſtarres, or elſe vpon certaine falſe and groſſe rules of the Guards and Pole ſtarres. Wherefore I haue thought good that as I haue ſhewed the way to knowe the Variation, vpon any one Obſeruatiſon, cyther in fore- noone, or after- noone, the latitude of the place preſuppoſed. So likewiſe vpon two Obſeruatiſons by the Sunne, either in fore- noone or afternoone: to ſet downe the way and manner howe to finde

of the Compasse.

Ande the Elevation of the Pole, scituation of the Meridian, and the Variation of the needle in any place by the Globe.

But this you must alwayes regard, that your two Observations may haue convenient distance of time betwix them, the greater the better: so as the higher Elevation be not taken nere the Meridian: The lower Elevation, the naxer it is taken to the Azimuth of East or West, or to the Horizon, the better: With which elevation, you are to note the difference of the sunnes Azimuths, or Variations, found by the shadowe vpon the Instrument exactly: For without that, the Elevations onely are in vaine.

First, it is requisite that your Globe be so fitted, that the Meridian circle and the Horizon doe crosse eache other at right angles, and deuide themselves equally into Semi-circles. And also that the Quadrant of altitude (or moueable Verticall) be placed duely vpon the Meridian circle, at the Zenith: so as being touched circularly, it may touch the Horizon equally in every part. These things being duely considered, there needeth not any further regard to be had for placing of the Globe, onely this you may respect in setting the Pole at aduētures aboute the Horizon, betwixne it and the Zenith, that the Meridian Circle may cut the Horizon in iust degrees, so may your Quadrant of altitude be placed in your Zenith, iustly vpon a degree also.

Then must you fasten your Globe to the Horizon, so as it may remaine immoueable: but in fastening the same, you must regarde that you force it not from one side of the Horizon to an other, but that it rest equidistant in the same: and hauing your Globe thus disposed, it is ready for you to applze your Observations vpon, which you shall thus doe.

First, take your highest elevation, and note it vpon your Quadrant of altitude, and place the ende of the said Quadrant vpon the Horizon, at 10. 15. or 20. from the Meridian

Of the Variation

bian circle (but the nearer you set the same to the Meridian, the more conveniently, without impeachment, will your trial be made.) Then giue a prick upon the Globe, in the azimuth, that the Quadrant sheweth at the degree of the elevation, noted upon the Quadrant: then again note the lesser Elevation vpon the Quadrant of altitude, and remove the same vpon the Horizon, (from that place where it was first fixed, towarde the azimuth of East or West, (which shalbe nearest the same) so many degrees as you find the difference of azimuths, betwene the two Elevations, by the shadow of the Sunne, vpon the instrument of Variation, and laying your Quadrant of altitude, vpon that point of the Horizon: note also your lesser elevation in the same azimuth vpon your Globe. This done, you must haue a paire of Calliper Compasses, such as may conveniently reach to 113. d. one sec: of the Equinoctiall of your Globe, (which is a Quadrant, and the greatest declination of the sunne:) Then you must consider which of the Poles of the world is elevated aboue your Horizon, and whether your declination be towards, or from that Pole, that is to say, whether the Sunne be betwene the elevated Pole, and the Equinoctiall, or the equinoctiall betwix the sunne and the Pole. If the sunne be betwene the Pole and the Equinoctiall, then are you to detract the declination from 90. d. If the Equinoctiall be betwix the Sun and the Pole, you must adde the declination, to 90. d. And take the same remaining or collected number of degrees, &c. with your compasses vpon the Equinoctiall. And set the one end of your compass at the prick made vpon your Globe, for the highest Observation, and with the other end describe an arch or pce of a circle, vpon the same side of the Meridian, that your prick is on, from the Meridian to the Horizon. Then againe with your compass vnaltered, setting the one foot in the prick, for the lowest obseruation, describe an other pce of a like circle, crossing the former: The point of the intersection, or crossing of these 2. circles, is the elevated Pole,

of the Compasse.

to the which if you remove the Quadrant of altitude, you shall see what the elevation thereof is. And the point that the same Quadrant sheweth vpon the Horizon, is the Intersection of the Meridian and the Horizon: The Horizontall distance betwene this intersection, and the azimuth of the lesser Observation, subtracted from the Semicircle, or 180. d. leaveth the Horizontall distance of the same azimuth from the true Meridian. So have you the elevation of the Pole, and situation of the Meridian.

Now if you compare the Horizontall distance of the Azimuth of the Sunne, from the Meridian, at the time of the Observation, with the Variation by the Sunnes Shadow found vpon the Instrument, at the time of the same Observation, and taking the one out of the other, the Remainder shall be the true Variation, which you are to account, as in the latter end of the third Chapter is shewed. So have you giuen the elevation of the Pole, the Meridian, and Variation of the needle: the things proposed to be shewed.

EXAMPLE OF TWO OBSER-

uations made at *Lym-house*, the 29.

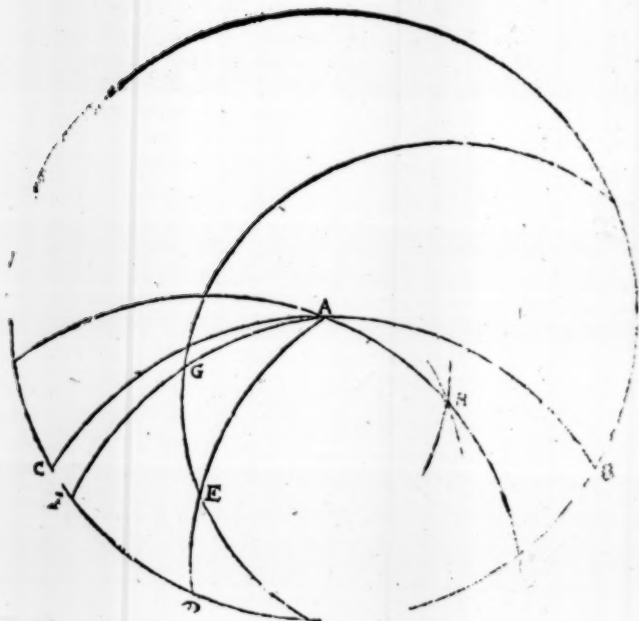
of *Julie*, 1581. in the

Fore-noone.

The first elevation 21. d. 0. m: Variation, 100. d. 30. m: from North to West. The second elevation, 50. d. 0. m: Variation, 48. d. 0. m: from North to West, Difference of the Azimuth, 52. d. 30. min: The Declination, 16. d. 14. min: Northerlie.

L Et IDB. be the Horizon of the Globe, CAB. the Meridian circle. FGA. the Azimuth of the greater elevation, shewed by the Quadrant of altitude, vpon the Horizon, at F. 10. d: from the Meridian circle of the Globe, CFG. the greater elevation, marked vpon the globe, at GFD
the

Of the Variation



the difference of the Azimuth, vpon the Horizon, 52. d. 30. mi. E. the prick of the lesser Eleuation marked vpon the Globe in the Azimuth. AED.

Then opening your Compasses, to 73. d. 46. min. of the Equinoctiall, (which is the complement of the Declination) and setting one ende vpon G. the point of the greater Eleuation, describe with the other ende, an Arch, as piece of a circle at H.

This done, set one foot of the Compass vnaltered in E. the lesser Eleuation, and with the other ende describe a piece of a circle, crossing the former Arch, at H. This intersection

Of the Compasse.

on shall be the eleuated Pole.

Then set the Quadrant of Altitude vnto the point H. and it will shewe the Meridian to crosse the Horizon at K. So shall you haue the Eleuation of the Pole, KH. 51. D: 1. sec: of there about. And the true Meridian, KAL. And frō K. to D. the Horizontal distance, 90. d: fourths, which subtracted frō KL. 180. d: the semicircle of the Horizon, resteth the arch, DL. 89. d: 1. fourth: the distace of the azimuth of the first Obseruation from the Meridian, I. Which distance compared with the variation found vpon the instrument, at the first eleuation, 100. d: 30. m: and deducted frō the same, resteth 11. d: 1. fourth. Therefore (I say) the true Meridian shewing y^e Pole Arlike is 11. d: 1. fourth to the Westwardes of the Magneticall Meridian, shewed by the needle: and consequently the Variation of the needle, 11. d: 1. forth: from the North to the East.

In this Example the declination is subtracted from the Quadrant, because the Sunne is betwene the Equinoctiall and the eleuated Pole, but if the Equinoctiall were betwene the eleuated Pole and the Sunne, then should you adde the declination to the Quadrant, and with that distance taken vpon the Equinoctiall with your compasses, proceede as in the former example.

These Examples that I haue shewed, and such like Experimentes to bee done vpon the Globe, are easie to bee conceived, and the Reasons very manifest: but the truth of the matter, consisteth in the exactnesse of the Instrumentes, and the orderly Application, and handling of them.

I might heere haue annerred the manner, how vpon two Obseruations of the Sunnes eleuation in Forenoone or Afternoone, and differences of the Azimuthes, to Calculate the Premises more exactly by the Table of Sines, and doctrine of Sphericall Triangles: but that it is a very tedious way, and my meaning is rather to giue the Reader a p^roofe of the pleasant vse of these Calculations,

¶

(which

Of the Variation

(which I thinke I haue sufficiently done in the former Chapters) then to cloie him at the first with the hard and painefull practise of many examples. Notwithstanding, for the satisfaction of some, I will briefly set down the ground and summe of the worke, which is this.

The complements of your two eleuations, are two sides of a sphericall triangle not rectangle. The angle by these two knowne sides contained at the Zenith, is given by the difference of the Azimuthes or Variations vpon the instrument. Wherefore by the 28. of the 4. of Regiomontanus the third side (which is the arch comprehended betwene the two eleuations) and the other angles may be giuen.

Then haue you another like triangle, whose three sides are these: the first, one of the foresaid complements of eleuation: the second, the arch of the circle of declination, betwene the Sun at the instant of the same eleuation, and the Elenated Pole. The third side is an arch of the Meridian betwene the Zenith and the Pole: which is the complement of the eleuation of the Pole, or latitude of the place.

The two first sides are alwaies giuen. For finding the third side, it is necessarie to knowe the angle that the two giuen sides contains, which is the difference of two angles, whereof one is an angle of the first Triangle giuen, the other an angle contained betwene the arch of the circle of declination, and the third side of the first Triangle, which angle is aduersely found, and being found and subtracted from the other angle, or that from it, the difference is the Angle of this other Triangle: And so haue you in the Sphericall Triangle two sides, and the angle by the same two sides contained giuen. And by the same 28. of the fourth of Regiomontanus the third side is found, the complement whereof is the eleuation of the Pole.

And the eleuation of the Pole, and declination of the Sunne

Of the Compasse.

Summe being given, the fourth Chapter sheweth by one obseruation, to finde the variation of the needle.

Of the Pole of the Magnes.

CHAP. VIII.



Wuers learned men haue iudged, and set downe as a truth (grounded vpon report) that the meridian common to the Pole of the world, and the Pole of the Magnes (that is to say, where the needle touched with the Magnes, sheweth the Pole of the world direc-

ly) passeth at the Ilands of the Acores, or nere thereabout, (but I know by great probabilitie, that it should be to the westwards of those Ilands.) From which meridian at the Acores, I account the beginning of Longitudes, and find our Meridian of London, to be from the same, 23. d. one second our Latitude as before said. 51. d. 32. m. and the variation of the Compas or needle. 11. d. one fourth from the north to the eastwards. Now vpon these grounds I finde by calculation, the Pole of the Magnes, or the intersection of the two Magneticall meridians, vpon the superficies of the earth, to be from the Pole artik 25. d. 44. m. in longitude 180. d. that is to say, 25. d. 44. m. in the former common Meridian, on the other side of the Pole.

It may be happily that some of you will be desirous to knowe the way how this Magneticall Pole is found out, that you may applie the same to like purpose hereafter. Wherefore I thought good to set downe the manner of the former calculation, by helpe of the declinations in the figure following.

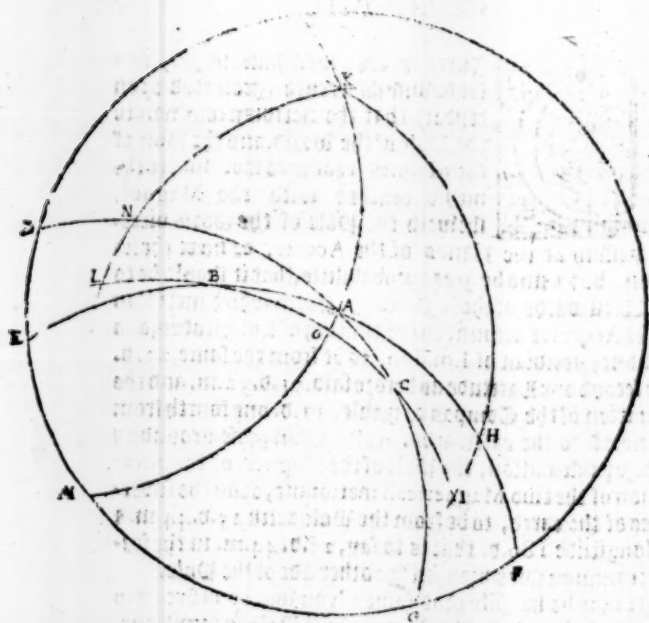
Example.

Let A, be the Pole Artike. PEF, the Equinoctial. DAG the common Meridian of the Pole Artik, and Pole of the

Of the Variation

the Magnes, EAF. the Meridian for London,

LOI. The Magneticall-Meridian of London, B. for the place of London. HI. the quantitie of the Angle of Variation, at the end of the Quadrants, BH, and BI. C, the in-



tersections of the two Magneticall-Meridians, CL. and CN. two Quadrants of the said Magneticall circles, including the arch LN. the quantitie of the angle, at C. PAM. the Semicircle of a Meridian, crossing the Magneticall-Meridian of London, in the point O. at right angles.

Make out the Quadrants, IHK. and LNK. so shall they crosse theielves with the Quadrant, OAK, at the point K. Now

Of the Compasse.

Now haue you ABC a sphericall triangle, two angles whereof, and the common containing side of them, are giuen ABC. 11 d. one fourth, the angle of variation at London. BAC. 156. d. 30. min. the complement of the angle DAE (the difference of the longitudes) to 2. right angles. And the side AB. 38. d. 28. min. the complement of the latitude of London. And in a sphericall triangle, not rectangle, whose two angles are giuen, and their common containing side, the other angle and sides shall be knowne by the 13. of the 4. of Regiomontanus.

Wherefore the arch AC. the distance of the two poles shalbe giuen, which is the thing required.
For as the sine of BH is to the sine of HI, so is the sine of BA. to the sine of AO. & three of them being giuen, the 4. is found.

90. min.	11.15. min.	38.28. min.	658. min.
BH	HI	BA	AO

If 100000. giue 19509.—then 61205. giueth 12135.

Now as AK is to AA (the sines I meane) so is KO to OI, but the three first are known AK & AH, by their complements, and KO the quadrant: therefore the 4 is giuen.

83.2. min.	51.32. min.	90.0.	52.4. min.
KA	HA	KO	OI

If 99211, giue 78297. — then 100000. giueth 78879.
And as BA is to BO. (the complement of the arch OI. last found) so is AE. to EM. the quantitie of the angle BAO.

38.28. min.	37.56. min.	90.0. min.	81.12. min.
AB.	BO	AE	EM

If 62205. giue 61474.—then 100000. giueth 98824.

So hauing EM. 18. d. 12. min. the quantitie of the angle BAO I subtract the same from EG. 15 d. 30. min. the quantitie of the whole angle BAC. rest MG. 75. d. 18. min. the quantitie of the angle CAO. to the which is equall, the apofite angle PAD. And as AP. is to PD. so is AK to AN

Of the Variation

90.m.	75.18.m.	83.2.m.	73.46.
AP	PD	KA	KN

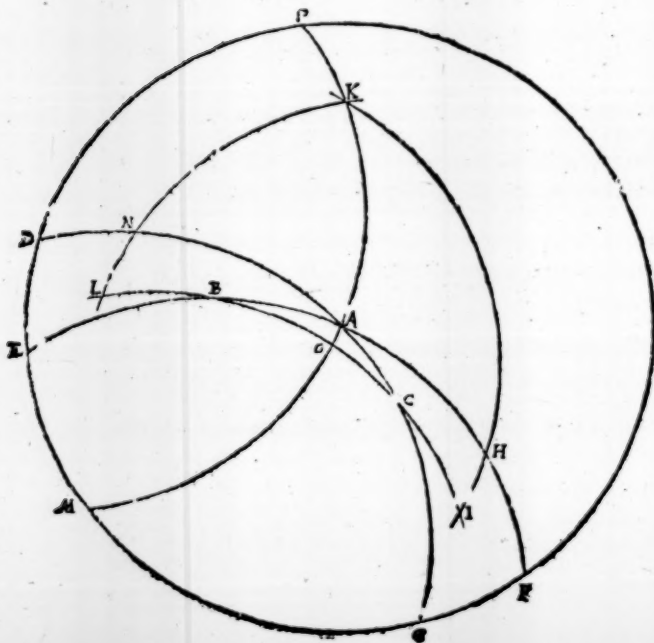
If 100000.giue 96726.—then 99261, giueth 96011.m.

The complement of which arch KN is NL, 16.d.14.m. the quantitie of the angle ABC. And as NL, is to CN, so is AO to AC. Wherefore I say,

16.14.m.	65.8.m.	35.44.m.	
NL	NC	AO	AC.

If 27954. giue 100000,—then 1 135 giueth 43410.

Which is the distance of the pole of the Magnes from the Pole artike vpon the former Hypothesis, the thing that was sought, Of



Of the Compasse.

Of the point Respective.

CHAP. IX.



Having shewed in the former Chapter, upon the grounds therein specified, the place of the Pole of the Magnes upon the superficies of the earth: there resteth now to be declared of the point respective, where it should be, by the new propertie found of the declining of the needle, being at this place for London, 71. d. 50. m. as in the former treatise by R. Norman.

First it is to be considered, that as the Magnetical meridians do crosse themselves at their pole before specified: so doe their plaines likewise crosse in a right line, passing by the said Pole, and the center of the earth. When producing a straight line in the magneticall plaine of London, declining from the plaine of the Horizon 71. d. 15. m. where the same both crosse with the former common section of the two plaines, there by reason should the point Respective be. Which intersection I finde to be from the center of the earth 1085. miles (after the rate of 60. to be a degree in the equator, & 3436. $\frac{1}{4}$. for the Semidiameter of the Earth) and the distance of the same from the axis of the world 471. miles.

For example.

Let the circles be as in the last demonstration, then shall LBC be the distance of the pole of the Magnes from the Zenith B. And Q. the center of the Earth. QA. the axis of the world. QC the common section of the Magneticall playnes. BZ. the lyne of the Needles Declination crossing the said common section at R. (which is the point respective.) QT a straight line crossing BZ. at right

of the Compasse.

If 98.750. giue 100000 — then 31178. giueth 31572.

So haue IQR. in such parts as the Semidiameter of the earth. QC. is 100000. which (beeing reduced into miles, accounting 3436. $\frac{1}{11}$. for the semidiameter of the earth) doe giue 1084. miles and $\frac{1}{11}$. which is the distance of the poynt respectiue R. from the center of the earth Q. vpon the former Hypothesis of the variation and declination of the magneticall needle.

Again, as QC. is to CY. so is QR. to RS. wherefore QC and QR. being giuen as before, and CY. the sine of the arch CA. likewise knowne RS. shalbe giuen.

90.m.	25.44.m.		
QC.	CY.	QR.	RS.

If 100000. giue 43410. — then 31572. giueth 13705.

Which being in the partes of the sines, I reduce into miles as before, and find the same 470. miles, and $\frac{1}{11}$. which is the distance of the point respectiue R. from the axis of the world QA. By the former Hypothesis.

CHAP. X.

Of the application of the variation, to the vse of Nauigation.



Vpon the Hypothesis of the pole of the Poles on the superficies of the earth, and the poynt Respectiue in the body thereof, according to the former calculations, might be inferred many pleasant conclusions, both for the longitude and latitude of places.

But as touching the poynt Respectiue by the declining of the needle, seeing this is the first and onely experiment that hath bene made of it, I cannot inferre any further matter thereof, than that which I haue already set down, vntill by obseruations in other places, we finde how it will holde.

And

Of the Variation

And as for the variation, if it were generally regular and certaine, as in some part it seemeth to be: (that is to say, from hence Westwardes to Meta Incognita, New-found-land, Florida, and that part of the coast of America) then might there be giuen by it generall rules, commodious for the vse of nauigation.

And by the same Hypothesis of the Pole of the magnes at 25.44.m. frō the Pole of the world, the greatest variation of the needle in the Equinoctiall, should be (at 50.d. of Longitude) 25.44. min. from north to East, and consequently the greatest variation in the Paralell of 70.d. should be (at the Longitude of 128.d. 51.m. from north to East 81.d. 14.m. And in the meridian of 180.d. of longitude betwene the two Poles (the Pole articke I meane, & the supposed Pole of the Magnes, there should the north point of the needle or compasse respecting his owne pole, shew the south, and the south point the north pole of the world.

But in my trauailes to the north East parts, I haue found this position of the Magneticall Pole cleane reuersed: for whereas the angle of Variation from hence Eastwards in the Paralell of 70.d. should encrease and growe wider, till it came to 81.d. 14.m. from north to East as before. At the Iland Vaigats being in longitude from London, 58.d. and in the same Paralell of 70.d. where, by the former Hypothesis, the variation should be 49.d. 22.m. frō north to East. I finde the needle to varie 7. degrees from north to West. And the like effect I haue found by diuers obseruations in sundry other places of the east partes, which obseruations, with many more that I haue caused to be made, and daily porture to be done in diuers other Countries, I reserue, with intent (if it be possible) to find some Hypothesis for the saluing of this apparant confused irregularitie.

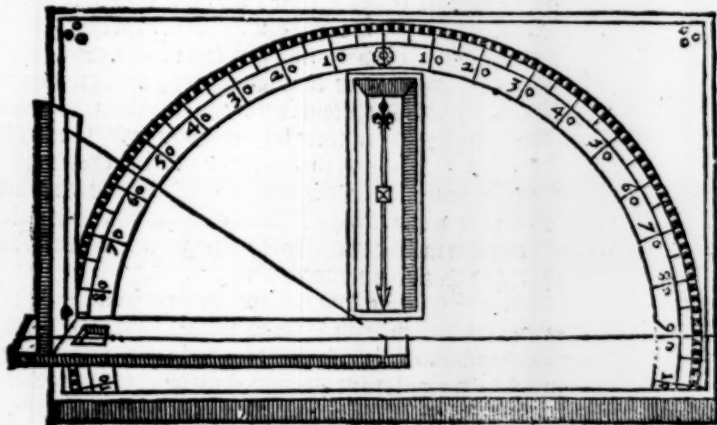
At Rati-bona, or Regensburg in Bauaria, being in latitude 48.d. 52.m. & in longitude 36.d. 20.m. where, by the former position of the Magneticall Pole at 25.d. 44.m. the varia-

of the Compasse.

Variation should be 16. d. 44. m. from north to East. Gerardus Mercator, found the same to be onely 11. 3. fourths as I gather by his placing of the Magneticall Pole at 16. d. 22. m. from the Pole arctike, upon his observation made at that place : which confirmeth the retrograde qualitie in the variation from hence Eastwards, as afoze said.

Which strange varietie, I haue here plainly proposed, to the end that the learned sort might consider thereof, and sharpening their wits, see what probable causes & grounds they can assigne for the same. For considering it remaineth alwaies constant without alteration in enery seuerall place, there is hope it may be reduced into method & rule.

A new Instrument for the Variation.



Because I haue found some imperfections in the first instrument for the variation (which notwithstanding both farre excell the compasses of variation heretofore vsed for that purpose) I haue here set down the forme of a new Instrument,

Of the Variation

Instrument to herein all scruple of doubts and defects that might growe by other is quite anorded. Which being once exactlie placed with the needle vpon the line of South and north, will serue without remouing for a whole daies obseruation, the Index onely being carried about with the Sunne, to giue the degrees of Azimuth vpon the Instrument by the shadowe of the line thereof, and is otherwise to be vied according to the prescript rules of the former Instrument.

Of the inconueniences and defects in sayling, and in description of Countries, caused by the variation of the Compasse.

CAAP. XI.

In all Sea Chartes generally which are made without consideration of the variation, are committed greater errors and confusion. For, either the partes therein contayned, are framed to agree in their latitudes by the skale thereof, and wrested from the true courses that one place beareth from another by the Compasse, or else in setting the parts to agree in their due courses, they haue placed them in false latitudes, or abridged, or ouerstretcht the true distaunces betwene them.

In the Marine Plats made for Newfoundland, the course set downe from Sillie to Cape Rasó is due West, which is found to be so for our common sayling Compasse, whose wiers are set one second a point from north to East, notwithstanding Sillie being in latitude 50.º. little more. Cape Rasó in Newfoundland is found to be but in 46.º. one third, which is 3.º. 2. thirds lesse then the latitude of Sillie. To make a shew of reformation of this error, caused by the variation and setting of the wiers in the (Compasse) to giue a light of that difference in longitude, they haue

of the Compasse.

have placed in the Plat against that Coast a newe scale of Latitude: Some vpon the Line of South and north, and some other haue placed the same vpon the Line of north-north-East, and South, South-West, (because the poynt of the Compasse theweth the pole nearest in that place,) and haue furnished the degrees thereof agreeable to the Latitude of Cape Rasor: and by that meanes haue had a double scale of Latitude; One for the Easterne-Coasts, the other for that West. But how farre the same hath bene from reforming the errour, or giuing any helpe to navigation, you may easily iudge.

Others, to auoyde that errour of the difference in Latitude, in that Voyage and Course; haue vsed Compasses, whose Nylers haue bene sette directly vnder the north poynt, and thereby sayling West from Sylic, haue fallen to the north-wards of Cape Rasor, about 50. leagues, and in Latitude, nere 49. d.

Some other haue vsed in the same Voyage, to place a blanke Nyle vpon theyr sayling-compass, which they haue remoued from time to time, as they haue iudged the Variation hath altered: by which way, albeit they may seeme to keepe themselves nerer the Paralell, yet the same in navigation, woorketh the greatest confusion of all other, and therefore is to be utterly abolished.

In our Voyages from hence Eastwards to S. Nicholas in Russia, and to the Narue, in Liuania, &c. The sea-rine-plats of the Coasts are described by our common-sayling Compass, with consideration of the Variations at diuers places, whereby the true Meridians reforme themselves, declining from the paralell-Meridian of our plat, doe necessarily lyden north-wards, and straighten to the South-wards: contrary to the true forme and nature of Meridians. And yet notwithstanding, that is the best meanes hitherto knowne, to reforme in Plat, the errours that else would growe, by the strange Variations that way.

And

Of the Variation

And albeit these plates serue very well for those navigations, yet by meanes of the variations considered, the forme of those coastes is so distorted from the right shape it should beare, being truely described vpon the globe, or otherwise in plaine, according to the true latitude and longitude: That whereas the Narue (being in Latitude 59. d. 1. fourth, and in Longitude from the Meridian of London 26. d. 16. m.) should be from S. Nicholas 9. d. 40. min. in longitude to the Westwards (S. Nicholas being in Latitude 64. d. 35. min. and in longitude from London 35. d. 50. m.) in the sailing Plat it is brought to be in the meridian of Colmogorod, (which is in latitude 64. d. 20. m. & in longitude from London 37. d. 45. m.) which is 1. d. 55. to the Eastwards of the meridian of S. Nicholas. Into the Mediterranean Sea, and in the coastes thereof wherein by great reason should be the perfectest descriptions of the world, for that in those parts haue bene the seates and abodes of the most famous and learned men in all ages, we see notwithstanding in the marine Plats of those parts, grosse errors committed, though want of knowledge of the variation, and the use thereof, in which they haue not accounted of 3. 4. or 5. degrees error in the latitude of places.

But those defects of the latitude haue bene very well reformed, by the famous and learned Gerardus Mercator (whom I honor and esteeme as the chiefe Cosmographer of this time) in his vniuersall Map, which though he haue made with sailing lines, & dedicated to the use of Seamen, yet for want of consideration of the variation, the same is more fit to be beheld, as study in Cosmographie, by reading authors vpon the land, then to be used in navigation at the sea.

There is also in the same vniuersall Mappe, and likewise in all other moderate Maps of the north parts of Europe, a great fault, by placing two Wardhouses distant one from the other about 20. d. in longitude, whereas in,

of the Compasse.

indeed they are but one thing, and no such distance betwene them. This error hath growne by taking Wardhouse, and the sea coastes, from thence to W. Nicolas Vaignats, and the Ob. &c. out of the Map of that worthy traualer, M. Anthonie Ienkinsons his journey to Boghar & Persia, &c. in the which I placed that border of the Sea coast, and for some causes went no further Westwardes in that description, then Wardhouse which is in latitude 70. d. 1. third, & in longitude from London 29. d. Wherefore to accomplish the whole border of that coast, he was forced to take some other description to ioyne with it, and toke as appeareth the Map of Olaus Magnus of the north Countries, wherein he found likewise Wardhouse, but falsely placed in latitude about 19. d. too much, & in longitude as much too little, the which, although he might take to be the same specified in Maister Ienkinsons Map, yet he was constrained to separate them the said distance of 20. d. in longitude (or to leaue there so much superfluous room) otherwise he should haue thrust the South parts of those Countries together, and confounded the whole description.

And albeit he had the entire sailing Plat, that we vse for those parts, yet if he had not knowne the secret effect of the Variation in the making thereof, he might haue fallen into the like absurditie or worse. But of those coastes and of the inward parts of the Countries, Russia, Muscouia, &c. I haue made a perfect Plat and description, by mine owne experience in sundrie voyages and trauailes, both by Sea and Land, to and fro in those parts, which I gaue to her Maiestie in Anno. 1578.

Besides these and like imperfections proceeding of the Variation, there is yet another inconuenience, which oftentimes increaseth the former errors, and that is, the diuers placing of the wires, fixed to the File of the Compass.

This varietie of setting the wires, hath caused great
confu-

Of the Variation

confusion in Nauigation, and in other Accountes of Sea-
causes: For when it is said, that from such a head-land,
to such a place, in such a Courſe, or at ſuch a place, the
Rowne vppon ſuch a poynt of the Compaſſe, maketh the
full-ſea; It is requiſite to be demaunded, by what Com-
paſſe the Obſeruatiſon was made, whereas if the Myers
had not bene altered from the north poynte of the Rye,
(which I wiſh had neuer bene any where) theſe doubts had
bene auoyded.

It belongeth therefore all men that will make Hydro-
graphicall Deſcriptions for the uſe of Sayling, to haue
ſpeciall regard of the Compaſſe by which theſe Obſeruati-
ons are made: and if they collect notes made by ſundry
Compaſſes of diuerſe Settes, they ought to reduce all the
Varieties vnto ſome one certaine, and to giue notice of the
ſame in theſe Plat: And not to make a confused mingle
mangle, by ioyning together all Varieties of Obſeruati-
ons, notes, and reports, as the Portugales and Spanyards
haue done, in compounding theſe North-partes of the
World, with theſe ſeuere Diſcoueries, without conſidera-
tion of the diuers ſorts of the ſeuereall Compaſſes by which
they were made.

Alſo it importeth all Maſters, Pilots, and others, by
what name ſoeuer, that ſhall giue Directions in nauiga-
tion, to looke circumſpectly to the ſetting of the Myers of
the Compaſſe by which they ſhall Sayle, that the ſame
Compaſſe be correſpondent to the lines of the Sea-Carde
that they ſhall uſe: (that is to ſay,) that it be of the ſame
ſet for the Variation, that the Compaſſe was of, by which
the Carde was made.

And ſeing we haue in this our Countrey, acquainted
our ſelues commonly in our Obſeruatiſons, and nauigati-
ons, with the Compaſſe, whole Myers are ſet at 1. ſec: a
poynt from north to Eaſt, I meane in the Deſcriptions
that I ſhall make, to applye the ſame agreeable to the ſaide
Compaſſe, and would uſe the like without alteration, (and
alſo

Of the Compasse.

to the straight lines in Sea Cards) if I should saile round about the worlde to make the description thereof, but alway with regarde of the feneral variations of euery place, where the same should be obserued.

Of the Instruments and rules in Nauigation.

CAP. XII.

Amongst the rules and Instrumentes for nauigation, all such are vaine and to small purpose, wherein the true Meridian is presupposed to be giuen by the Magneticall needle, without due consideration of the Variation; for that they are all grounded vpon false suppositions. Whereby it commeth to passe, that one Michael Coigenet of Antwerp, in his New Instruction (as he termeth it) of the most excellent and necessary points of Nauigation, wherein he sheweth the making and vse of a Nauticall Hemisphere, which he preferreth before all other Sea Instruments, is very childishly abused. For whereas he pretendeth by it, to giue the eienation of the Pole, and the houre and instant of the time of the daie, by any one obseruation in any place: besides that, it is of all other that hath hitherto bene vsed at Sea, the most tedious and vnfit for that purpose: it is also by reason of the variation not considered, more false and erroneous. For the true Meridian (which is the ground of his purpose, is as farre to seeke as the thing he promiseth to giue by the same. The like may be sayd of all other Instrumentes made vpon the same ground, whether they serue for the Sea or land.

The same author in the 4. Chapter of his booke, entreating of sailing vpon the pointes of the Compasse, sayth, that in sailing South or north, he shall passe by the poles

Of the Variation

of the world, and keepe vnder one Meridian, till he come to the place from whence he first departed. And vpon the points of East and West out of the Equinoctiall, he shall saile vnder a Paralell, till he returne to the place from whence he went. But in sailing vpon the point of north-East, he shall describe a spirall line inclining by little and little towards the Pole, as in his demonstration thereof in the same Chapter appeareth. But for want of due consideration of the variation, his rules, reasons, and demonstrations, and such others hitherto giuen for like purposes are frivolous and false.

For if he direct his sailing by the Compasse (as of necessity he must, being the onely instrument for that purpose) it is manifest, that whether he saile north or South, East or West, or by what other point soeuer, the Compasse not respecting alwaies the Pole of the World, as he supposeth, but some other point or points distant from the same, shall leave him accordingly, whereby he shall neither keepe vnder one Meridian, nor vnder one paralell of latitude, neither make such a spirall line to the Pole of the world, as he demonstrateth. His fault in setting downe those rules is so much the greater, in that he acknowledgeth in the Chapter next before the variation at Antwerpe, to be about 9. d. from north to East, according to Mercators position, of the Magnetical Pole, which he also confirmeth by his owne experience.

But it seemeth he hath followed that excellent Mathematician Petrus Nonius, especially concerning the sailing vpon the points of East and West. For he, in his first booke of the rules and instruments of navigation, enforceth himselfe to proue and demonstrate, that in sailing East or West out of the Equinoctiall, the course is performed by partes of great circles, and yet describeth a paralell. But how that may stand with the principles of Geometrie, I referre the iudgement to the expert Mathematicians, for it is like as a circle should be made

Of the Compasse.

made of straight lines, which is impossible.

It appeareth in the discourse that he hath made of those matters, that he had not a right iudgement of the nature of the Compasse in sailing (admitting the same to shew the Pole without Variation) for if he had, he would neuer haue entered in such a Labyrinth as he did. But he thought it a great absurditie, that the compasse in euery Horizon, should shew the Meridian & Poles of the worlde by the points of north and South, and by the points of East and West, to shew in the Horizon the verticall and Equinoctiall East and West, (being a great circle) and yet in sailing East or West, except in the Equinoctiall, it should perforce be but a paralell.

But it is to be understode, that albeit the points or lines of the Compasse, do alwaies in euery Horizon represent great circles in the Heauenes, the points of South and north the Meridian, and the points of East and west the verticall circle of East and West, each crossing other at right angles, and likewise of the points. (The reason whereof is, because the Compasse lieth euery where leuel with the Horizon, so as a perpendicular line descending from the center thereof at right angles with the playne of the same, will alwaies fall vpon the center of the earth, and consequently be the Semidiameter of a great circle) so that wheresoeuer the Compasse be caried, these circles are supposed to be caried about with it, and the viewe of euerie thing in the Horizon, represented by the pointes thereof, is likewise in great circle: Yet in sailing by the Compasse, the points of South and north onely, describe great circles generally, which are the Meridians, and the points of East and West, describe a great circle in the Equinoctiall onely: in all other places out of the Equinoctiall, they describe but Paralels. And the sailing vpon any other point of the Compasse from any place, describeth a spirall line, according to the angle it maketh with the Meridian. And hereby in sailing vpon the

Of the Variation

points of East or West, out of the Equinoctial,) the north point alwaies respecting the pole (the course performeth a Paralell, according to the distance of the center of the Compass from the pole. The manner thereof you may perceiue by fastning a small thrid or Virginnall wier at the Pole of a Globe, or center of a circle, which shall represent a moueable Meridian to be carried about the globe or circle, and fixe vpon the same, a small flie of a Compass, so as the line of South and north be answerable to the thrid or wier, and the north point thereby alwaies respect the north pole: then in turning the thrid about the Globe or circle, vpon the Pole or center, if the center of the flie be out of the equinoctiall, (betwæne it and the Pole) albeit the pointes of East and West, crossing the same line and moueable meridian at right angles, doe shew the Verticall East and West vpon the Globe, which is a great circle, yet in carring the same flie vpon the thrid or moueable meridian about the pole or center, you shall by the center of the same flie describe but a Paralell according to the distance thereof from the Pole of the Globe, or center of the circle, not vnlke the circular motion of a horse drawing in a Mill, who though he looke forth straight in a right line, yet being fastned to the beame of the Mill, is forced to make his course in a circle, whose semidiameter is the length of the beam contained betwæne the horse and the center of your mill or millpost.

And as in the Equinoctiall, the line of South and north in the Compass (by supposition representing the Meridian) is paralell to the Axis of the earth, (which is the common section of all the Meridian planes,) and the line of East and West, crossing the same Axis at right angles, representeth the verticall East and West, which is the Equinoctiall, imagining to descend from the center of the Compass a line, to fall perpendicularly, and at right angles with the Axis of the world (which shall be at the center of the earth) and in sailing East or West by the compass,

of the Compasse.

pasſe, the imagined perpendicular line being carried about, with the ſame (making alwaies right angles with the axis) ſhall deſcribe the plaine of the Equinoctiall, Equidistant from the Poles of the world, and at right angles with the axis: and the point of the ſame line at the center of the Compasse, the circumference of the Equinoctiall, vpon the ſuperficies of the Sea: ſo being from the Equinoctiall on either ſide, imagining the line of South and North in your Compasse, to preſent alwaies the Axis of the world, and to lie Paralell with it, the line of Eaſt and Weſt muſt croſſe the ſame axis alwaies at right angles: And ſuppoſing a line to fall from the center of your Compasse to the axis of the world, making right angles with the ſame axis. In ſaying Eaſt or Weſt, that imagined line being carried about with the Compasse (alwaies at right angles with the axis) ſhall deſcribe the plaine of a paralell, equidistant to the plaine of the Equinoctiall, and the point thereof at the center of the Compasse, the circumference of the paralell vpon the ſuperficies of the ſea: which Paralell ſhould be repreſented by the points of Eaſt & Weſt of the compasse, if the line of ſouth and north of the ſame, were Paralell to the axis of the Poles, as was ſuppoſed, but it is not. And therefore, as they decline one from y other, ſo doth the verticall circle of Eaſt and Weſt ſhewed by the Compasse, decline from the paralell circle euery where.

The angle of which declination is alwaies equall to the latitude of the place, or diſtance of the Paralell from the equinoctiall.

But as I haue already ſufficiently declared, the compasse ſheweth not alwaies the Pole of the world, but varieth from the ſame ſometimes, and in ſailing deſcribeth circles accordingly. Which thing, if Petrus Nonius and the reſt that haue written of nauigation, had ſoyntly conſidered in the tractation of their rules and Inſtruments, then might they haue bene more available to the vſe of

Of the Variation

Navigation, but they perceiving the difficulties of the thing, and that if they had dealt therewith, it would have utterly overwhelmed their former plausible conceits, with Pedro de Medina (who as it appeareth having some small suspicion of the matter, reasoneth very clearly, that it is not necessarie that such an absurditie as the Variation, should be admitted in such an excellent art as Navigation is) they have all thought best to passe it over with silence. But letting that passe, let these few following examples make knowne to the Judicious, what is fittest to be conceived in their experimentall practises.

Certaine briefe and necessarie propositions, nauticall to be performed Arithmetically by the tables of sines, *Tangents*, and *Secants*.

The principall thing that is chiefly to be considered in the art of navigation, is to know directly, or so neare as Art may performe, the true p^ricke or place, of the ships being at any instance in the tyme of her voyage, which may be done to a certaine nearenes, though not precisely many waies: but Arithmeticall Calculation being the most perfect, is therefore most to be regarded. For the knowledge of which p^ricke or place of the ship, 4. things are principally to be desired and knowne (viz.) difference of Latitude, departure fro the meridian, or difference of Longitude, the true course that your ship hath made good her way upon, and the distance or number of leagues of way that she hath gone, of which any two being given you, may by the tables of Sines Tangents and Secants, find eyther of the other two. For by the difference of Latitude and course is found the distance. And againe, by the difference of Latitude and distance, is found out the course: also by the course and difference of Lat: is knowne the departure from the Meridian, and consequently the difference of Longitude. For the better understanding whereof, these few propositions

of the Compasse.

positions following will sufficiently instruct you.

Proposition. 1.

The difference of Latitude, and distance given to find the course.

As the leagues of difference of Latitude is to the whole sine, so is the leagues of your distance to the secant of your courses, distance from South or North.

Example.

Suppose that you have altered your Latitude one degree to which 20. leagues is answerable, and that you have sailed 36. leagues from the place where you made your last observation Southwesterly, I desire to knowe upon what point I have sailed? For the knowledge whereof, I say according to the former rule, if 20. leagues the difference of Lat. require 10000. the whole sine for his proportionall part, what is the secant that 36. leagues shall require for his proportionall part, I multiplie 10000. the whole sine by 36. the Leagues of distance, whose product being 360000, I divide by 20. the leagues of difference of Latitude. Whose quotient 18000, I seek in the table of secants, whose arke I finde nearest to be 56. degrees 15. in. for the courses distance to the westwardes of the South, that divided by 11. one fourth, gives 5. points or 50. W. and by west.

Proposition. 2.

The difference of Latitude and course being knowne, to find the departure from the Meridian, and consequently the Longitude.

As the whole sine is to the leagues of difference of Latitude: so is the tangent of the courses distance from South or North, to the leagues of departure from the

Of the Variation

the meridian.

Example.

Having altered the Latitude one degree, and sailed South West & by West, which is 56. degrees 15. m. to find $\frac{1}{2}$ leagues of departure, I multiplie 14966. the tangent of 56. degrees 15. min. the courses distance by 20. the leagues of difference of Latitude, whose product 299320. I divide by 10000. the quotient whereof 29. and nine tenths, is the leagues that I am departed from the Meridian, having altered the latitude one degree upon that course, which is very neare 90. minutes, or one, & one halfe degree of a great circle, for the difference of longitude, or otherwise converted into miles or minutes, & divided by the minutes that make a degree in the latitude, where you finde your selfe to be, it gives you the difference of Longitude in the said paralell.

Proposition. 3.

The courses and difference of Latitude given to finde the distance.

As the whole line is to the minutes of difference of Lat. so is the Secant of the courses distance from South or north to the miles of distance.

Example.

The difference of Latitude one degree or 60. miles, and the courses distance, 56. d. 5. m. from South to West to finde the distance, I multiplie 18. by 16. the minutes of difference of Lat. whose product 1080000. divided by 10000. the whole line, the quotient thereof is 108. miles, or 36. leagues that the ship hath sailed upon that course to alter one degree of Latitude.

Prop. 4.

Of the Compasse.

Proposition 4.

By course and departure from the Meridian, to finde the difference of Latitude.

As the whole line is to the miles of departure from the Meridian, so is the Tangent of the courses distance from East or West, to the minutes of difference of Latitude.

Example.

Being departed from the Meridian 90. miles, and the course sailed upon Southwest by West, which is 33. degrees 55. minutes from the East or West to finde the difference of Latitude, I multiply 6723. the Tangent of the courses distance from West by 90. the miles of departure from the Meridian, the product 605070. I deuide by 10000. the whole line, the quotient 60. is the minutes of difference of Latitude.

These few Propositions are sufficient for the examining and correcting of a dead reckoning, upon any course or distance whatsoever: but first for the better knowledge of the said dead reckoning, it is necessarie to haue this following Table, either alwaies by you, or els perfect in your memory, which giues you 1. for each point and halfe point, the degrees and minutes that belongs to it. (2) the leagues and parts of leagues that raise or lay a degree upon each point. (3) the leagues, and the parts of leagues, that you depart from the former Meridian in raising or laying a degree, vpon each said point and $\frac{1}{2}$ point.

S. b. W.	11. 15.	20. $\frac{1}{2}$.	3. $\frac{1}{4}$.
S. b. W. $\frac{1}{2}$.	16. 52.	20. $\frac{2}{3}$.	6.
S. S. W.	22. 30.	21. $\frac{3}{4}$.	8. $\frac{1}{2}$.
S. S. W. $\frac{1}{2}$.	28. 7.	22. $\frac{1}{2}$.	10. $\frac{1}{4}$.
S. W. b. S	33. 45.	24.	13. $\frac{1}{4}$.
S. W. b. S. $\frac{1}{2}$	39. 22.	25. $\frac{1}{2}$.	16. $\frac{3}{4}$.
Southwest	45.	28. $\frac{1}{2}$.	20.
S. W. $\frac{1}{2}$	50. 37.	31. $\frac{1}{2}$.	24. $\frac{1}{2}$.
S. W, b. W.	56. 15.	36	29. $\frac{1}{4}$.
S. W, b. W. $\frac{1}{2}$.	61. 52.	42. $\frac{1}{2}$.	37. $\frac{1}{4}$.

H

W.S.W.

Of the Variation.

W. S. W.	67. 30.	52. $\frac{1}{2}$.	48. $\frac{1}{2}$.
W. S. W. $\frac{1}{2}$.	73. 7.	6 $\frac{1}{2}$.	65. $\frac{1}{2}$.
W. b. S.	78. 45.	102. $\frac{1}{2}$.	100 $\frac{1}{2}$.
W. by S. $\frac{1}{2}$.	84. 22.	203. $\frac{1}{2}$.	202. $\frac{1}{2}$.

How to finde the angle of position vpon a *Trauerse* of
seuerall points.

Suppose your ship haue gone vpon these seuerall points
following viz. S. W. W. S. W. S. S. E. & E. S. E
vpon the first point 8. leagues, vpon the second 10. leagues,
vpon the third 12. and vpon the fourth 9. leagues.

Now to bring all these into one direct course, with the
difference of Latitude and Longitude, whereby is knowne
the true angle of position, you must worke for each point
seuerally, first for the difference of Latitude according to
that proportion that each point requires for the raising or
laying of a degree: As first for the Southwest.

I see in the former Table that 28. leagues and $\frac{1}{2}$ raise
a degree, therefore omitting the fraction: I say if 28. leag.
requires 60. for his difference of Lat: what shall 8. leagues
running vpon the same point require: by which working I
finde that in running 8. leagues, Southwest 17. $\frac{1}{2}$. Again,
for my depart from the Meridian, vpon the same point and
distance, I see in the said former Table, that in altering
your Lat: 60. min. or in running 28. leagues Southwest,
you are departed from your Meridian 20. leagues, there-
fore you either say, if in running 28. leagues, the departure
from the Meridian is 20. leagues, what shall 8. leagues
running vpon the same point giue: or you may say if 60.
min, difference of Latitude giue 20. leagues departure,
what shall 17. min. giue: the one will be 5. $\frac{1}{2}$. the other 5.
and $\frac{1}{2}$ which is in a manner all one, which small difference
in the 2. seuerall workings, is by omitting the fractions.
Thus hauing found the difference of Latitude, and depar-
ture from the Meridian for the first point and distance,
worke in the like manner for all the rest, and set them
downe

Of the Compasse.

done in order one vnder the other: first the points, next the leagues runne vpon each point: thirdly the difference of Latitude, fourthly, the departure from the Meridian: and lastly, whether the course be Easterly or Westerly, the Table following sheweth the same, each point ready brought perticularly.

points.	Leags of dist:	min. of Lat:	departur from y Merl.
S. W.	8.	17. $\frac{1}{4}$	5. $\frac{1}{4}$ Westerly.
W. S. W.	10.	11. $\frac{1}{4}$	9. $\frac{1}{4}$ Westerly.
S. S. E.	11.	30.	4. Easterly.
E. S. E.	19	10. $\frac{1}{4}$	8. $\frac{1}{4}$ Easterly.

This done, to bring all the severall courses into one direct line, being that all these courses are southerly, I adde the minutes of difference of Lat: together, and they are 69 min. nearest or 1. degree 9. minutes, for the difference of Latitude: Then for the departure from the Meridian, I adde first the Westerly course by it selfe, which is 5. $\frac{1}{4}$ and 9. $\frac{1}{4}$. that is nearest 14. $\frac{1}{4}$. then I adde the Easterly course of departure by it selfe, (viz.) 4. and 8. $\frac{1}{4}$. makes 12. $\frac{1}{4}$. the one deducted from the other, leaues 2. $\frac{1}{4}$. leagues, nearest that I haue departed from the first Meridian to the Westwards in all the said severall courses, being that the Westerly way is so much more then the Easterly, so by this way we haue you 2. things knowne, viz. difference of Lat: and departure from the Meridian, thereby to finde the other 2. (viz.) course and distance, for which, 2 other propositions will giue you satisfaction, as followeth.

Proposition 5.

By difference of Latitude and departure from the Meridian to finde the course.

As the miles of the departure from the Meridian is in proportion to the whole line, so is the miles or minutes of difference of Latitude, to the Tangent of the courses distant from East or West.

B 2

Example.

Of the Variation.

Example.

In the former woꝝke the difference of Latitude was 69, 1 min. 02 miles, and the departure from the Meridian is 2. $\frac{1}{2}$ leagues, 02 7. $\frac{1}{2}$ myles, therefore I say, if 7. $\frac{1}{2}$ giue 10000. what giues 69 minuts? facit 92000, whose nearest arche in the Table of Tangents 83 deg. 48 min. is the courses distant from the West Southerly: that taken from 90, the number of degrees betwene the West and South, leaueth 6 deg. 22 min. which is somewhat moze then halfe a point, that the course is to the Westwards of the South: so haue you now the difference of Latitude, the departure from the Meridian, and the course. The distance is then giuen by the third Prop: 02 otherwayes thus, but to woꝝke by the third Prop: is best.

Proposition 6.

The difference of Latitude, and the departure from the Meridian being knowne to finde the distance.

Square the miles of difference of Latitude, and the miles of departure from the Meridian, adde both the squares together, and from the product extract the square roote, which root is the distance.

Example.

The difference of Latitude 69 miles, the square thereof 5761. the departure from the Meridian 7 $\frac{1}{2}$ miles, the square thereof 112 $\frac{1}{2}$ both added together 5873. $\frac{1}{2}$ whose square roote 76 miles 02 25 leagues, is the distance required.

But this way is not in my iudgement altogether so true as the woꝝking by the Table of Sines and Secants, for by this it is 25, and by the other as is shewed in the 3 Propo: it is but 23, which I holde the truest. *Item rule 4.*

Whosoever desireth moze exquisitnes in this kinde of Arithmaticall sailing: let him practise B. Petiscus his doctrine of Triangles, lately translated into our vulgar tongue, by Mr. R. Handson for the benefit chiefly of our English Marriners, and other practisers in the Mathematickes.

FINIS.



A Canon of Triangles:

O R

The Tables, of Sines,
Tangents & Secants,

The RADIUS assumed
to be 100000.



*That since 1/4 minute is 0.00029088820866 &c
of a second is 0.00004840136811 &c*

A TABLE OF

o	Sines		Tangents		Secants		
1	29	100000	29	343774667	100000	343774682	59
2	58	99999	58	171887319	100000	171887348	58
3	87	99999	87	114591530	100000	114591573	57
4	116	99999	116	85943630	100000	85943689	56
5	145	99999	145	68754887	100000	68754960	55
6	175	99999	175	57295721	100000	57295809	54
7	204	99999	204	49110600	100000	49110702	53
8	233	99999	233	42971757	100000	42971873	52
9	262	99999	262	38197099	100000	38197230	51
10	291	99999	291	34377371	100000	34377516	50
11	320	99999	320	31252137	100001	31252297	49
12	349	99999	349	28647773	100001	28647948	48
13	378	99999	378	26444080	100001	26444269	47
14	407	99999	407	24555198	100001	24555402	46
15	436	99999	436	22918166	100001	22918385	45
16	465	99999	465	21485760	100001	21485995	44
17	494	99999	494	20221875	100001	20222122	43
18	524	99999	524	19098419	100001	19098680	42
19	553	99998	553	18093220	100002	18093496	41
20	582	99998	582	17188540	100002	17188831	40
21	611	99998	611	16370020	100002	16370325	39
22	640	99998	640	15625908	100002	15626228	38
23	669	99998	669	14946502	100002	14946837	37
24	698	99998	698	14323712	100002	14324061	36
25	727	99997	727	13750745	100003	13751108	35
26	756	99997	756	13221851	100003	13222229	34
27	785	99997	785	12732134	100003	12732526	33
28	814	99997	814	12277395	100003	12277803	32
29	844	99996	844	11854018	100004	11854440	31
30	873	99996	873	11458865	100004	11459301	30

Let s , be $\frac{1}{2}$ Line of an Arch; then $\frac{1}{2} \text{SS} - \text{SSSS}$
 equal to $\frac{1}{2}$ Line of $\frac{1}{2}$ double an

A TABLE OF

O	Sines		Tangents		Secants		
31	902	99996	902	11089205	100004	11089655	29
32	931	99996	931	10742648	100004	10743114	28
33	960	99995	960	10417094	100005	10417574	27
34	989	99995	989	10110690	100005	10111185	26
35	1018	99995	1018	9821794	100005	9822303	25
36	1047	99995	1047	9548948	100005	9549471	24
37	1076	99994	1076	9290849	100006	9291387	23
38	1105	99994	1105	9046334	100006	9046886	22
39	1134	99994	1134	8814357	100006	8814924	21
40	1164	99993	1164	8593979	100007	8594561	20
41	1193	99993	1193	8384351	100007	8384947	19
42	1222	99993	1222	8184704	100007	8185315	18
43	1251	99992	1251	7994343	100008	7994968	17
44	1280	99992	1280	7812634	100008	7813274	16
45	1309	99991	1309	7639001	100009	7639655	15
46	1338	99991	1338	7472917	100009	7473586	14
47	1367	99991	1367	7313899	100009	7314583	13
48	1396	99990	1396	7161507	100010	7162205	12
49	1425	99990	1425	7015335	100010	7016047	11
50	1454	99989	1455	6875001	100011	6875736	10
51	1483	99989	1484	6740185	100011	6740927	9
52	1513	99989	1513	6610547	100011	6611303	8
53	1542	99988	1542	6485801	100012	6486572	7
54	1571	99988	1571	6365674	100012	6366460	6
55	1600	99987	1600	6249915	100013	6250715	5
56	1629	99987	1629	6138291	100013	6139105	4
57	1658	99986	1658	6030582	100014	6031411	3
58	1687	99986	1687	5926587	100014	5927431	2
59	1716	99985	1716	5826117	100015	5826975	1
60	1745	99985	1745	5728996	100015	5729869	0

Handwritten notes on the right margin:
 The first column of numbers is the Sines of the Arch.
 The second column of numbers is the Tangents of the Arch.
 The third column of numbers is the Secants of the Arch.
 The fourth column of numbers is the Sines of the double Arch.
 The fifth column of numbers is the Tangents of the double Arch.
 The sixth column of numbers is the Secants of the double Arch.

A TABLE OF

I	Sines	Tangents	Secants	
1	1774 9998	1775 5635059	100016 5635946	59
2	1803 9 98	1804 5544152	100016 5545053	58
3	1832 9 98	1833 5456130	100017 5457046	57
4	1862 9 983	1862 5370859	1000 7 5371790	56
5	1891 9 983	1891 5288211	100018 5289156	55
6	1920 9 982	1920 5208067	100018 5209027	54
7	1949 9 981	1949 5130316	100019 5 31290	53
8	1978 9 980	1978 5054851	100020 5 55840	52
9	2007 9 980	2007 4981573	100020 4982576	51
10	2036 99979	2036 4910388	100021 4911406	50
11	2065 99979	2066 4841208	100021 4842241	49
12	2094 99978	2095 4773950	100022 4774997	48
13	2123 99977	2125 4708534	100023 4709596	47
14	2152 99977	2153 4644886	100023 4645963	46
15	2181 99976	2182 4582235	100024 4584026	45
16	2211 99976	2211 4522614	100024 4523719	44
17	2240 99975	2240 4463860	100025 4464980	43
18	2269 99974	2269 4406611	100026 4407746	42
19	2298 99974	2298 4350812	100026 4351961	41
20	2327 99973	2328 4296408	100027 4297571	40
21	2356 99972	2357 4242346	100028 4244525	39
22	2385 99972	2386 4191579	100028 41 2772	38
23	2414 99971	2415 4141059	100029 4142266	37
24	2443 99970	2444 4091741	100030 4092963	36
25	2472 99969	2473 4043584	100031 404 820	3
26	2501 99969	2502 3996546	100031 399 797	34
27	2530 99968	2531 3950589	100032 395 855	33
28	2560 99967	2560 39056 7	100033 3906957	32
29	2589 99966	2589 3861774	100034 3863068	31
30	2618 99966	2619 3818846	100034 3820155	30

*Let's be y^e Line of an Arch then 35-4555 is
y^e Line of y^e Triple Arch*

A TABLE OF.

I	Sines	Tangents	Secants	
31	264799965	26483776861	1000353778185	29
32	267699964	26773735789	1000363737127	28
33	270599963	27063695600	1000373696953	27
34	273499963	27353656266	1000373657633	26
35	276399962	27643617760	1000383619141	25
36	279299961	27952580055	1000393581452	24
37	282199960	28223543128	1000403544539	23
38	285099959	28513506955	100041350838	22
39	287999959	2881311511	1000413472951	21
40	290899958	29103436777	1000423438232	20
41	293899957	29393492730	1000433404199	19
42	296799956	29683369351	1000443370835	18
43	299699955	29973336619	1000453338118	17
44	302599954	30263304517	1000463306030	16
45	305499953	30553273026	1000473274554	15
46	308399952	30843242129	1000483243671	14
47	311299952	31143211810	1000483213366	13
48	314199951	31433182052	1000493183623	12
49	317099950	31723152839	1000503154425	11
50	319999949	32013124158	1000513125758	10
51	322899948	32303095993	1000523097607	9
52	325799947	32593068331	1000533069960	8
53	328699946	32883041158	1000543042802	7
54	331699945	33173014462	1000553016120	6
55	334599944	33462988230	1000562989903	5
56	337499943	33762962450	1000572964137	4
57	340399942	3405237111	1000582938812	3
58	343299941	34342912200	1000592913917	2
59	346199940	34632887709	1000602889440	1
60	349099939	34922863625	1000612865371	0

11 *Let's be a degree of height in Arch, then is 223, the
Course. Find off whole Arch find being - 12*

A TABLE OF

2	Sines		Tangents		Secants		
1	3519	99938	3521	2839940	100062	2841700	59
2	3548	99937	3550	2816643	100063	2818418	58
3	3577	99936	3579	2793724	100064	2795513	57
4	3606	99935	3609	2771175	100065	2772980	56
5	3635	99934	3638	2748986	100066	2750805	55
6	3664	99933	3667	2727149	100067	2728982	54
7	3693	99932	3696	2705656	100068	2707503	53
8	3723	99931	3725	2684498	100069	2686359	52
9	3752	99930	3754	2663668	100070	2665543	51
10	3781	99929	3783	2643164	100072	2645055	50
11	3810	99927	3812	2622966	100073	2624872	49
12	3839	99926	3842	2603074	100074	2604994	48
13	3868	99926	3871	2583481	100075	2585416	47
14	3897	99924	3900	2564180	100076	2566129	46
15	3926	99923	3929	2545179	100077	2547135	45
16	3955	99922	3958	2526435	100078	2528413	44
17	3984	99921	3987	2507975	100079	2509969	43
18	4013	99919	4016	2489782	100081	2491790	42
19	4042	99918	4046	2471848	100082	2473873	41
20	4071	99917	4075	2454175	100083	2456212	40
21	4100	99916	4104	2436747	100084	2438898	39
22	4129	99915	4133	2419570	100085	2421636	38
23	4159	99913	4162	2402627	100087	2404712	37
24	4188	99912	4191	2385925	100088	2388020	36
25	4217	99911	4220	2369453	100089	2371562	35
26	4246	99910	4250	2353200	100090	2355329	34
27	4275	99909	4279	2337174	100091	2339313	33
28	4304	99907	4308	2321367	100093	2323520	32
29	4333	99906	4337	2305766	100094	2307934	31
30	4362	99905	4366	2290376	100095	2292558	30

TABLE OF

2

Sines

Tangents

Secants

31	4391	99904	4395	2275189	100097	2277386	29
32	4420	99902	4424	2260202	100098	2262413	28
33	4449	99901	4454	2245410	100099	2247635	27
34	4479	99900	4483	2230810	100100	2233050	26
35	4507	99898	4512	2216398	100102	2218653	25
36	4536	99897	4541	2202170	100103	2204440	24
37	4565	99866	4570	2188124	100104	2190408	23
38	4594	99894	4599	2174255	100106	2176553	22
39	4623	99893	4628	2160563	100107	2162873	21
40	4653	99892	4658	2147041	100108	2149368	20
41	4682	99890	4687	2133682	100110	2136024	19
42	4711	99889	4716	2120493	100111	2122849	18
43	4740	99888	4745	2107467	100113	2109838	17
44	4769	99886	4774	2094595	100114	2096981	16
45	4798	99885	4803	2081884	100115	2084284	15
46	4827	99883	4833	2069321	100117	2071736	14
47	4856	99882	4862	2056913	100118	2059342	13
48	4885	99881	4891	2044647	100119	2047091	12
49	4914	99879	4920	2032531	100121	2034989	11
50	4943	99878	4949	2020557	100122	2023030	10
51	4972	99876	4978	2008719	100124	2011206	9
52	5001	99875	5007	1997022	100125	1999524	8
53	5030	99873	5037	1985460	100127	1987977	7
54	5059	99872	5068	1974031	100128	1976562	6
55	5088	99870	5095	1962731	100130	1965277	5
56	5117	99869	5124	1951557	100131	1954117	4
57	5146	99867	5153	1940512	100133	1943087	3
58	5175	99866	5182	1929591	100134	1932180	2
59	5205	99864	5212	1918792	100136	1921396	1
60	5234	99863	5241	1908112	100137	1910731	0

A TABLE OF

3	Sines	Tangents	Secants	
1	5263 99861	5270 1897550	100139 1900183	59
2	5292 99860	5299 1887104	100140 1889752	58
3	5321 99858	5328 1876773	100142 1879434	57
4	5350 99857	5357 1866552	100143 1869229	56
5	5379 99855	5387 1856446	100145 1859137	55
6	5408 99854	5416 1846444	100147 1849150	54
7	5437 99852	5445 1836549	100148 1839270	53
8	5466 99850	5474 1826763	100150 1829498	52
9	5495 99849	5503 1817977	100151 1819826	51
10	5524 99847	5533 1807495	100153 1810260	50
11	5553 99846	5562 1798911	100155 1800796	49
12	5582 99844	5591 1788628	100156 1791421	48
13	5611 99842	5620 1779342	100158 1782150	47
14	5640 99841	5649 1770152	100159 1772974	46
15	5669 99839	5678 1761056	100161 1763892	45
16	5698 99838	5708 1752052	100163 1754903	44
17	5727 99836	5737 1743139	100164 1746005	43
18	5756 99834	5766 1734316	100166 1737197	42
19	5785 99833	5795 1725582	100168 1728477	41
20	5814 99831	5824 1716935	100169 1719844	40
21	5844 99829	5853 1708374	100171 1711298	39
22	5873 99827	5883 1699896	100173 1702835	38
23	5902 99825	5912 1691502	100175 1694456	37
24	5931 99824	5941 1683191	100176 1686159	36
25	5960 99822	5970 1674963	100178 1677945	35
26	5989 99821	5999 1666812	100180 1669809	34
27	6018 99819	6029 1658739	100182 1661751	33
28	6047 99817	6058 1650747	100183 1653773	32
29	6076 99815	6087 1642828	100185 1645868	31
30	6105 99813	6116 1634987	100187 1638041	30

A TABLE OF

3	Sines	Tangents	Secants	
31	6134 99812	6145 1627217	100189 1630207	29
32	6163 99810	6175 1619523	100190 1622607	28
33	6192 99908	6204 1611898	100192 1614997	27
34	6221 99806	6233 1604348	100194 1607461	26
35	6250 99804	6262 1596868	100196 1599996	25
36	6279 99803	6291 1589455	100198 1592598	24
37	6308 99700	6321 1582111	100200 1585269	23
38	6337 99799	6350 1574835	100201 1578006	22
39	6366 99797	6379 1567624	100203 1570811	21
40	6395 99795	6408 1560479	100205 1563680	22
41	6424 99793	6437 1553399	100207 1556614	19
42	6453 99792	6461 1546381	100209 1549612	18
43	6482 99790	6496 1539427	100211 1542672	17
44	6511 99788	6525 1532535	100213 1535794	16
45	6540 99786	6554 1525706	100215 1528979	15
46	6569 99784	6584 1518935	100216 1522223	14
47	6598 99782	6613 1512223	100218 1515526	13
48	6627 99780	6642 1505572	100220 1508890	12
49	6656 99778	6671 1498978	100222 1502310	11
50	6685 99776	6700 1492441	100224 1495788	10
51	6714 99774	6730 1485960	100226 1489321	9
52	6743 99772	6759 1479536	100228 1482912	8
53	6773 99770	6788 1473167	100230 1476557	7
54	6802 99768	6817 1466853	100232 1470257	6
55	6831 99766	6847 1460592	100234 1464011	5
56	6860 99764	6876 1454384	100236 1457817	4
57	6889 99762	6905 1448228	100238 1451676	3
58	6918 99760	6934 1452123	100240 1445586	2
59	6947 99758	6963 1436069	100242 1439547	1
60	6976 99756	6993 1430066	100244 1433558	0

B

A TABLE OF

	Sines	Tangents	Secants	
1	7005 99754	7022 1424112	100246 1427619	59
2	7034 99752	7051 1418208	100248 1421729	58
3	7063 99750	7080 1412353	100250 1415889	57
4	7092 99748	7110 1406545	100252 1410095	56
5	7121 99746	7139 1400785	100254 1404350	55
6	7150 99744	7168 1395071	100257 1398650	54
7	7179 99742	7197 1389404	100259 1392998	53
8	7208 99740	7227 1383783	100261 1387392	52
9	7237 99738	7256 1378207	100263 1381829	51
10	7266 99736	7285 1372675	100265 1376312	50
11	7295 99734	7314 1367187	100267 1370839	49
12	7324 99731	7344 1361743	100269 1365410	48
13	7352 99729	7373 1356341	100271 1360022	47
14	7382 99727	7402 1350982	100274 1354677	46
15	7411 99725	7431 1345664	100275 1349375	45
16	7440 99723	7461 1340388	100278 1344113	44
17	7469 99721	7490 1335156	100280 1338896	43
18	7498 99719	7519 1329958	100282 1333714	42
19	7527 99716	7548 1324803	100284 1328572	41
20	7556 99714	7578 1319689	100287 1323473	40
21	7585 99712	7607 1314613	100289 1318411	39
22	7614 99710	7636 1309577	100291 1313389	38
23	7643 99708	7665 1304577	100293 1308404	37
24	7672 99705	7695 1299617	100296 1303458	36
25	7701 99703	7724 1294693	100298 1298549	35
26	7730 99701	7753 1289805	100300 1293676	34
27	7759 99699	7782 1284955	100302 1288841	33
28	7788 99696	7812 1280142	100305 1284042	32
29	7817 99694	7841 1275363	100307 1279278	31
30	7846 99692	7870 1270521	100309 1274549	30

A TABLE OF

4

	Sines	Tangents	Secants	
31	7873 99689	7899 1265912	100311 1269856	29
32	7904 99687	7929 1261238	100314 1265197	28
33	7933 99685	7958 1256600	100316 1260571	27
34	7962 99683	7987 1251993	100318 1255980	26
35	7991 99680	8017 1247422	100321 1251424	25
36	8020 99678	8046 1242882	100323 1246898	24
37	8049 99676	8075 1238376	100325 1242407	23
38	8078 99673	8104 1233903	100328 1237947	22
39	8107 99671	8134 1229460	100330 1233520	21
40	8136 99668	8163 1225050	100333 1229125	20
41	8165 99666	8192 1220672	100335 1224761	19
42	8194 99664	8221 1216324	100337 1220428	18
43	8223 99661	8251 1212006	100340 1216125	17
44	8252 99659	8280 1207719	100342 1211852	16
45	8281 99657	8309 1203462	100345 1207610	15
46	8310 99654	8339 1199235	100347 1203397	14
47	8339 99652	8368 1195037	100349 1199213	13
48	8368 99649	8397 1190868	100352 1195099	12
49	8397 99647	8427 1186728	100354 1190934	11
50	8426 99644	8456 1182618	100357 1186838	10
51	8455 99642	8485 1178533	100359 1182768	9
52	8484 99639	8514 1174479	100362 1178728	8
53	8513 99637	8544 1170450	100364 1174714	7
54	8542 99635	8573 1166450	100367 1170729	6
55	8571 99632	8602 1162477	100369 1166769	5
56	8600 99630	8632 1158529	100372 1162838	4
57	8629 99627	8661 1154609	100374 1158932	3
58	8658 99625	8690 1150716	100377 1155053	2
59	8687 99622	8720 1146848	100379 1151199	1
60	8716 99619	8749 1143006	100382 1147372	0

B 2

185

TABLE OF

<i>S</i>	<i>Sines</i>	<i>Tangents</i>	<i>Secants</i>	
1	8754 99617	8778 1139189	100385 1143569	59
2	8774 99614	8807 1135397	100387 1139792	58
3	8802 99612	8837 1131631	100390 1135040	57
4	8831 99609	8866 1127889	100395 1132313	56
5	8860 99607	8895 1124172	100395 1128611	55
6	8889 99604	8925 1120478	100397 1124932	54
7	8918 99601	8954 1116809	100400 1121278	53
8	8947 99599	8983 1113164	100403 1117647	52
9	8976 99596	9013 1109543	100405 1114039	51
10	9005 99594	9042 1105944	100408 1110455	50
11	9034 99591	9071 1102369	100411 1106895	49
12	9063 99588	9201 1098816	100413 1103357	48
13	9092 99586	9130 1095286	100416 1099841	47
14	9121 99583	9159 1091778	100419 1096348	46
15	9150 99580	9189 1088292	100421 1092877	45
16	9170 99578	9218 1084829	100424 1089428	44
17	9208 99575	9247 1081388	100427 1086002	43
18	9237 99572	9277 1077969	100429 1082596	42
19	9266 99570	9306 1074569	100432 1079212	41
20	9295 99567	9335 1071192	100435 1075849	40
21	9324 99564	9365 1067835	100438 1072507	39
22	9353 99562	9394 1064499	100440 1069186	38
23	9382 99559	9423 1061184	100443 1065886	37
24	9411 99556	9453 1057889	100446 1062606	36
25	9440 99553	9482 1054615	100449 1059346	35
26	9469 99551	9511 1051361	100451 1056106	34
27	9498 99548	9541 1048126	100454 1052885	33
28	9527 99545	9570 1044911	100457 1049685	32
29	9556 99542	9600 1041715	100460 1046505	31
30	9585 99540	9629 1038540	100462 1043343	30

TABLE OF

	Sines	Tangents	Secants	
31	961499537	96581035382	1004631040200	29
32	964299334	96881032244	1004681037077	28
33	967199531	97171029125	1004711033972	27
34	970099528	97461026025	1004741030886	26
35	972999526	97751022943	1004771027819	25
36	975899523	98051019879	1004801024770	24
37	978799520	98341016833	1004821021739	23
38	981699517	98641013805	1004851018725	22
39	984599514	98931010795	1004881015730	21
40	987499511	99231007803	1004911012733	20
41	990399508	99521004828	1004941009792	19
42	993299506	99811001870	1004971006849	18
43	996199503	10011998930	1005001003923	17
44	999099400	10040996007	1005031001014	16
45	1001999497	10069993160	100506998123	15
46	1004899494	10099990211	100509995248	14
47	1007799491	10128987338	100512992389	13
48	1010699488	10158984482	100515989547	12
49	1013599485	10187981641	100518986722	11
50	1016499482	10216978817	100521983912	10
51	1019299479	10246976009	100523981118	9
52	1022199476	10273973216	100526978341	8
53	1025099473	10303970441	100530975579	7
54	1027999470	10334967679	100533972833	6
55	1030899467	10363964935	100536970103	5
56	1033799464	10393962204	100539967387	4
57	1036699461	10422959490	100542964687	3
58	1039599458	10452956790	100545962002	2
59	1042499455	10481954166	100548959332	1
60	1045399452	10510951436	100551956677	0

TABLE OF

6

Sines

Tangents

Secants

1	10482	99449	10540	948781	100554	954036	59
2	10511	99446	10569	946141	100557	951410	58
3	10540	99443	10599	943514	100560	948799	57
4	10569	99440	10628	940903	100563	946202	56
5	10597	99437	10657	938306	100566	943620	55
6	10626	99434	10687	935722	100569	941051	54
7	10655	99431	10716	933154	100573	938496	53
8	10684	99428	10746	930599	100576	935956	52
9	10713	99424	10775	928057	100579	933430	51
10	10742	99421	10805	925530	100582	930917	50
11	10771	99418	10834	923016	100585	928417	49
12	10800	99415	10863	920515	100588	925931	48
13	10829	99412	10893	918028	100592	923458	47
14	10858	99409	10922	915554	100595	920999	46
15	10887	99406	10952	913093	100598	918553	45
16	10916	99402	10981	910645	100601	916119	44
17	10945	99399	11011	908210	100604	913699	43
18	10973	99396	11040	905788	100608	911292	42
19	11002	99393	11070	903379	100611	908907	41
20	11031	99390	11099	900983	100614	906515	40
21	11060	99386	11128	898599	100617	904146	39
22	11089	99383	11158	896227	100621	901789	38
23	11118	99380	11187	893867	100624	899444	37
24	11147	99377	11217	891520	100627	897111	36
25	11176	99374	11246	889185	100630	894791	35
26	11205	99370	11276	886862	100634	892482	34
27	11234	99367	11305	884551	100637	890185	33
28	11263	99364	11335	882251	100640	887901	32
29	11291	99360	11364	879964	100644	885628	31
30	11320	99357	11394	877688	100647	883367	30

A TABLE OF

6

	Sines	Tangents	Secants	
31	11349	99354	11423	875424
32	1137	99351	11452	873171
33	11407	99347	11482	870930
34	11436	99344	11511	868701
35	11465	99341	11541	866482
36	11494	99337	11570	864275
37	11523	99334	11600	862079
38	11552	99331	11629	859893
39	11580	99327	11659	857719
40	11609	99324	11688	855555
41	11638	99320	11718	853402
42	11667	99317	11747	851260
43	11696	99314	11777	849128
44	11725	99310	11806	847007
45	11754	99307	11836	844896
46	11783	99303	11865	842796
47	11812	99300	11895	840706
48	11840	99297	11924	838656
49	11869	99293	11954	836556
50	11898	99290	11983	834496
51	11927	99286	12013	832446
52	11956	99283	12042	830406
53	11985	99279	12072	828376
54	12014	99276	12101	826356
55	12043	99272	12131	824345
56	12071	99268	12160	822344
57	12100	99265	12190	820353
58	12129	99262	12219	818371
59	12158	99258	12249	816398
60	12187	99255	12278	814435
			100630	881117
			100654	878879
			100657	876653
			100660	874437
			100664	872234
			100667	870041
			100671	867859
			100674	865688
			100677	863529
			100681	861380
			100684	859241
			100688	857113
			100691	854996
			100695	852890
			100698	850793
			100702	848708
			100705	846632
			100708	844567
			100712	842512
			100715	840466
			100719	838431
			100722	836406
			100726	834390
			100730	832384
			100733	830388
			100737	828402
			100740	826426
			100744	824458
			100747	822500
			100751	820551

A TABLE OF

7	Sines		Tangents		Secants		
1	12216	99251	12308	812481	100755	818612	59
2	12245	99247	12338	810536	100758	816682	58
3	12274	99244	12367	808601	100762	814761	57
4	12302	99240	12397	806674	100765	812849	56
5	12331	99237	12426	804756	100769	810946	55
6	12360	99233	12456	802848	100773	809052	54
7	12389	99230	12485	800949	100776	807167	53
8	12418	99226	12515	799058	100780	805291	52
9	12447	99222	12544	797176	100784	803423	51
10	12476	99219	12574	795302	100787	801565	50
11	12504	99215	12603	793438	100790	799714	49
12	12533	99211	12633	791582	100795	797874	48
13	12562	99208	12662	789734	100798	796040	47
14	12591	99204	12692	787895	100802	794215	46
15	12620	99200	12722	786064	100806	792399	45
16	12649	99197	12751	784241	100810	790591	44
17	12678	99193	12781	782427	100813	788792	43
18	12706	99189	12810	780622	100817	787001	42
19	12735	99186	12840	778824	100821	785218	41
20	12764	99182	12869	777035	100825	783443	40
21	12793	99178	12899	775253	100828	781676	39
22	12822	99175	12929	773480	100832	779917	38
23	12851	99171	12958	771715	100836	778167	37
24	12880	99167	12988	769957	100840	776424	36
25	12908	99163	13017	768208	100844	774689	35
26	12937	99160	13047	766466	100847	772967	34
27	12966	99156	13076	764732	100851	771242	33
28	12995	99152	13106	763005	100855	769530	32
29	13024	99148	13136	761287	100859	767826	31
30	13053	99144	13165	759576	100863	766130	30

A TABLE OF

7

	Sines	Tangents	Secants	
31	13081 99141	13195 757872	100867 764441	29
32	13110 99137	13224 756176	100871 762759	28
33	13139 99133	13254 754487	100875 761085	27
34	13168 99129	13284 752806	100878 759418	26
35	13197 99125	13313 751132	100882 757759	25
36	13226 99122	13343 749465	100886 756107	24
37	13254 99118	13372 747806	100890 754462	23
38	13283 99114	13402 746154	100894 752825	22
39	13312 99110	13432 744508	100898 751194	21
40	13341 99106	13461 742871	100902 749571	20
41	13370 99102	13491 741240	100906 747955	19
42	13399 99098	13521 739616	100910 746345	18
43	13427 99094	13550 737999	100914 744743	17
44	13456 99091	13580 736389	100918 743148	16
45	13485 99087	13609 734786	100922 741559	15
46	13514 99083	13639 733190	100926 739978	14
47	13543 99079	13669 731600	100930 738403	13
48	13572 99075	13698 730018	100934 736835	12
49	13600 99071	13728 728442	100938 735274	11
50	13629 99067	13758 726872	100942 733719	10
51	13658 99063	13787 725310	100946 732171	9
52	13687 99059	13817 723754	100950 730630	8
53	13716 99055	13846 722204	100954 729095	7
54	13744 99051	13876 720661	100958 727566	6
55	13773 99047	13906 719125	100962 726044	5
56	13802 99043	13935 717594	100966 724529	4
57	13831 99039	13965 716071	100970 723019	3
58	13860 99035	13995 714553	100975 721517	2
59	13889 99031	14024 713042	100979 720020	1
60	13917 99027	14054 711537	100983 718530	0

C

82

A TABLE OF

8	Sines		Tangents		Secants		
1	13946	99023	14084	710038	100987	717046	59
2	13975	99019	14113	708546	100991	715568	58
3	14004	99015	14143	707059	100995	714096	57
4	14033	99011	14173	705579	100999	712630	56
5	14061	99006	14202	704105	101004	711170	55
6	14090	99002	14232	702636	101008	709717	54
7	14119	98998	14262	701174	101012	708269	53
8	14148	98994	14291	699718	101016	706828	52
9	14177	98990	14321	698268	101020	705392	51
10	14205	98986	14351	696823	101024	703962	50
11	14234	98982	14381	695384	101029	702538	49
12	14263	98978	14410	693952	101033	701120	48
13	14292	98973	14440	692525	101037	699707	47
14	14320	98969	14470	691103	101041	698301	46
15	14349	98965	14499	689688	101046	696900	45
16	14378	98961	14529	688228	101050	695504	44
17	14407	98957	14559	686873	101054	694115	43
18	14436	98953	14588	685574	101059	692730	42
19	14464	98948	14618	684082	101063	691353	41
20	14493	98944	14648	682694	101067	689979	40
21	14522	98940	14678	681312	101071	688612	39
22	14551	98936	14707	679935	101076	687250	38
23	14580	98931	14737	678564	101080	685893	37
24	14608	98927	14767	677189	101084	684542	36
25	14637	98923	14796	675838	101089	683196	35
26	14666	98919	14826	674483	101093	681856	34
27	14695	98914	14856	673133	101098	680521	33
28	14723	98910	14886	671789	101102	679191	32
29	14752	98906	14915	670450	101106	677866	31
30	14781	98902	14945	669116	101111	676547	30

A TABLE OF

8

Sines

Tangents

Secants

31	14810	98897	14975	667787	101115	675233	29
32	14838	98893	15005	666463	101119	673924	28
33	14867	98889	15034	665145	101125	672620	27
34	14896	98884	15064	665831	101128	671321	26
35	14925	98880	15094	662525	101133	670027	25
36	14954	98876	15124	661219	101137	668738	24
37	14982	98871	15153	659921	101142	667455	23
38	15011	98867	15183	658627	101146	666176	22
39	15040	98863	15213	657339	101151	664901	21
40	15069	98858	15243	656055	101155	663633	20
41	15097	98854	15272	654777	101160	662369	19
42	15126	98849	15302	653503	101164	661110	18
43	15155	98845	15332	652234	101169	659855	17
44	15184	98841	15362	650961	101173	658605	16
45	15212	98836	15391	649710	101178	657361	15
46	15241	98832	15421	648456	101182	656121	14
47	15270	98827	15451	647206	101187	654885	13
48	15299	98823	15481	645960	101191	653655	12
49	15327	98818	15511	644720	101196	652429	11
50	15356	98814	15540	643484	101200	651208	10
51	15385	98809	15570	642253	101205	649991	9
52	15414	98805	15600	641026	101209	648779	8
53	15442	98800	15630	639804	101214	647572	7
54	15471	98796	15660	638586	101219	646369	6
55	15500	98791	15689	637373	101223	645170	5
56	15529	98787	15719	636165	101228	643976	4
57	15557	98782	15749	634961	101233	642787	3
58	15586	98778	15779	633761	101237	641602	2
59	15615	98773	15809	632566	101243	640421	1
60	15643	98769	15838	631375	101246	639245	0

C 2

81

A TABLE OF

9	Sines	Tangents	Secants	
1	15672 98764	15868 630188	101251 638073	59
2	15701 98760	15898 639006	101256 636906	58
3	15730 98755	15928 627828	101261 635742	57
4	15758 98751	15958 626655	101265 634584	56
5	15787 98746	15988 625486	101270 633429	55
6	15816 98741	16017 624321	101275 632279	54
7	15845 98737	16047 623160	101279 631132	53
8	15873 98733	16077 622003	101284 629990	52
9	15902 98728	16107 620851	101289 628853	51
10	15931 98723	16137 619703	101294 627719	50
11	15959 98718	16167 618559	101296 626590	49
12	15988 98714	16196 617419	101303 625464	48
13	16017 98709	16226 616283	101308 624343	47
14	16046 98704	16256 615151	101313 623226	46
15	16074 98700	16286 614023	101317 622113	45
16	16103 98695	16316 612899	101322 621004	44
17	16132 98690	16346 611780	101327 619899	43
18	16160 98686	16376 610664	101332 618792	42
19	16189 98681	16405 609552	101337 617700	41
20	16218 98676	16435 608444	101342 616607	40
21	16246 98671	16465 607340	101346 615517	39
22	16275 98667	16495 606240	101351 614432	38
23	16304 98662	16525 605144	101356 613350	37
24	16333 98657	16555 604051	101361 612273	36
25	16361 98652	16585 602963	101366 611199	35
26	16390 98648	16615 601878	101371 610129	34
27	16419 98643	16645 600797	101376 609062	33
28	16447 98638	16674 599720	101382 608000	32
29	16476 98633	16704 598646	101386 606941	31
30	16505 98629	16734 597577	101390 605886	30

A TABLE OF

9	Sines	Tangents	Secants	
31	16533 98624	16764 596511	101395 604835	29
32	16562 98619	16794 595449	101400 603787	28
33	16591 98614	16824 594390	101405 602743	27
34	16620 98609	16854 593335	191410 601703	26
35	16648 98604	16884 592284	101415 600666	25
36	16677 98600	16914 591236	101420 599633	24
37	16706 98595	16944 590192	101425 598603	23
38	16734 98590	16974 589151	101430 597577	22
39	16763 98585	17004 588114	101435 596555	21
40	16792 98580	17033 587080	101440 595536	20
41	16820 98575	17063 586050	101445 594521	19
42	16849 98570	17093 585024	101450 593509	18
43	16878 98565	17123 584001	101455 592501	17
44	16906 98561	17153 582901	101460 591496	16
45	16935 98556	17183 581965	101466 590494	15
46	16964 98551	17213 580953	101471 589497	14
47	16992 98546	17243 579944	101476 588602	13
48	17021 98541	17273 578938	101481 587511	12
49	17050 98536	17303 577936	101486 586523	11
50	17078 98531	17333 576937	101491 585539	10
51	17107 98526	17363 575941	101496 584558	9
52	17136 98521	17393 574949	101501 583580	8
53	17164 98516	17423 573960	101506 582606	7
54	17193 98511	17453 572974	101512 581635	6
55	17222 98506	17483 571992	101517 580667	5
56	17250 98501	17513 671013	101522 579703	4
57	17279 98496	17543 570037	101526 578742	3
58	17308 98491	17573 569064	101532 577784	2
59	17336 98486	17603 568095	101537 576829	1
60	17365 98481	17633 567129	101543 575877	0

A TABLE OF

IO	Sines	Tangents	Secants	
1	17393 98476	17663 566165	101548 574929	59
2	17422 98471	17693 565205	101553 573984	58
3	17451 98466	17723 564249	101558 573041	57
4	17479 98460	17753 563295	101564 572102	56
5	17508 98455	17783 562344	101569 571167	55
6	17537 98450	17813 561397	101574 570234	54
7	17565 98445	17843 560452	101579 569304	53
8	17594 98440	17873 559511	101585 568377	52
9	17623 98435	17903 558573	101590 567454	51
10	17651 98430	17933 557638	101595 566533	50
11	17680 98425	17963 556706	101600 565615	49
12	17708 98420	17993 555777	101606 564701	48
13	17737 98414	18023 554851	101611 563790	47
14	17766 98409	18053 553927	101616 562881	46
15	17794 98404	18083 553007	101622 561975	45
16	17823 98399	18113 552090	101627 561073	44
17	17852 98394	18143 551176	101633 560173	43
18	17880 98389	18173 550264	101638 559277	42
19	17909 98383	18203 549356	101643 558383	41
20	17937 98378	18233 548450	101649 557492	40
21	17966 98373	18263 547548	101654 556604	39
22	17995 98368	18293 546648	101649 555712	38
23	18023 98363	18323 545751	101665 554837	37
24	18052 98357	18353 544857	101670 553958	36
25	18081 98352	18383 543966	101676 553081	35
26	18109 98347	18414 543077	101681 552208	34
27	18138 98341	18444 542192	101687 551337	33
28	18166 98336	18474 541309	101692 550468	32
29	18195 98331	18504 540429	101698 549603	31
30	18224 98325	18534 539552	101703 548741	30

A TABLE OF

IO	Sines		Tangents		Secants		
31	18252	98321	18564	538677	101709	547881	29
32	18281	98315	18594	537806	101714	547024	28
33	18309	98310	18624	536936	101720	546169	27
34	18338	98304	18654	536070	101725	545317	26
35	18367	98298	18684	535206	101731	544468	25
36	18395	98294	18714	534345	101736	543622	24
37	18424	98288	18745	533487	101742	542778	23
38	18452	98283	18775	532631	101747	541937	22
39	18481	98277	18805	531778	101753	541099	21
40	18509	98272	18835	530928	101758	540263	20
41	18538	98267	18865	530080	101764	539430	19
42	18567	98261	18895	529235	101769	538600	18
43	18595	98256	18925	528393	101775	537772	17
44	18624	98250	18955	527553	101781	536947	16
45	18652	98245	18986	526715	101786	536124	15
46	18681	98240	19016	525880	101792	535304	14
47	18710	98234	19046	525048	101798	534486	13
48	18738	98229	19076	524219	101803	533671	12
49	18767	98222	19106	523391	101809	532859	11
50	18795	98218	19136	522567	101815	532049	10
51	18824	98212	19166	521745	101820	531241	9
52	18852	98207	19197	520925	101826	530436	8
53	18881	98201	19227	520108	101832	529634	7
54	18910	98196	19257	519293	101837	528834	6
55	18938	98190	19287	518481	101843	528036	5
56	18967	98185	19317	517671	101849	527241	4
57	18995	98179	19347	516863	101854	526448	3
58	19024	98174	19378	516058	101860	525658	2
59	19052	98168	19408	515256	101866	524870	1
60	19081	98163	19438	514455	101872	524084	0

A TABLE OF

II	Sines	Tangents	Secants	
1	19109 98157	19468 513658	101877 523301	59
2	19138 98152	19498 512862	101883 522521	58
3	19167 98146	19529 512069	101889 521742	57
4	19195 98140	19559 511279	101895 520966	56
5	19224 98135	19589 510490	101901 520193	55
6	19252 98129	19619 509704	101906 519421	54
7	19281 98124	19649 508921	101912 518652	53
8	19309 98118	19680 508139	101918 517886	52
9	19338 98112	19710 507360	101924 517121	51
10	19366 98107	19740 506584	101930 516359	50
11	19395 98101	19770 505809	101936 515600	49
12	19423 98096	19801 505037	101941 514842	48
13	19452 98090	19831 504267	101947 514087	47
14	19480 98084	19861 503499	101953 513334	46
15	19509 98079	19891 502734	101959 512583	45
16	19538 98073	19921 501971	101965 511835	44
17	19566 98067	19952 501210	101971 511088	43
18	19595 98061	19982 500451	101977 510344	42
19	19623 98056	20012 499695	101983 509603	41
20	19652 98050	20042 498940	101989 508863	40
21	19680 98044	20073 498188	101995 508126	39
22	19709 98039	20103 497438	102001 507390	38
23	19737 98033	20133 496690	102007 506657	37
24	19766 98027	20164 495945	102013 505926	36
25	19794 98021	20194 495201	102019 505197	35
26	19823 98016	20224 494460	102025 504471	34
27	19851 98010	20254 493721	102031 503745	33
28	19880 98004	20285 492984	102037 503024	32
29	19908 97998	20315 492249	102043 502303	31
30	19937 97992	20345 491516	102049 501585	30

A TABLE OF

11

Sines

Tangents

Secants

31	19965	97987	20376	490785	102055	500869
32	19994	97981	20406	490056	102061	500155
33	20022	97975	20436	489329	102067	499443
34	20051	97969	20466	488605	102073	498733
35	20079	97963	20497	487882	102079	498025
36	20108	97958	20527	487162	102085	497320
37	20136	97952	20557	486444	102091	396616
38	20165	97946	20588	485727	102097	495914
39	20193	97940	20618	485013	102103	495214
40	20222	97934	20648	484300	102110	494517
41	20251	97928	20679	483590	102116	493821
42	20279	97922	20709	482882	102122	493128
43	20307	97916	20739	482175	102128	492436
44	20336	97910	20770	481471	102134	491746
45	20364	97905	20800	480768	102140	491058
46	20393	97899	20830	480068	102147	490372
47	20421	97893	20861	479369	102153	489689
48	20450	97887	20891	478673	102159	489007
49	20478	97881	20921	477978	102165	488327
50	20507	97875	20952	477285	102171	487649
51	20535	97869	20982	476595	102178	486973
52	20563	97863	21013	475906	102184	486299
53	20592	97857	21043	475219	102190	485626
54	20620	97851	21073	474534	102196	484956
55	20649	97845	21104	473851	102203	484288
56	20677	97839	21134	473169	102209	483621
57	20706	97833	21164	472490	102215	482956
58	20734	97827	21195	471812	102221	482293
59	20763	97821	21225	471137	102228	481633
60	20791	97815	21256	470463	102234	480937

29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

D

78

A TABLE OF

12	Sines		Tangents		Secants		
1	20820	97809	21286	469791	102241	480316	59
2	20848	97803	21316	469121	102247	479661	58
3	20877	97797	21347	468452	102253	479007	57
4	20905	97790	21377	467786	102259	478355	56
5	20933	97784	21408	467121	102266	477705	55
6	20962	97778	21438	466458	102272	477057	54
7	20991	97772	21469	465797	102279	476410	53
8	21019	97766	21499	465138	102284	475766	52
9	21047	97760	21529	464480	102291	475123	51
10	21076	97754	21560	463824	102298	474482	50
11	21104	97748	21590	463170	102303	473843	49
12	21132	97742	21621	462518	102311	473205	48
13	21161	97735	21651	461868	102316	472569	47
14	21189	97729	21682	461210	102323	471935	46
15	21218	97723	21712	660572	102330	471303	45
16	21246	97717	21743	459927	102336	470672	44
17	21275	97711	21773	459283	102343	470044	43
18	21303	97705	21804	458641	102349	469417	42
19	21331	97698	21834	458001	102356	468791	41
20	21360	97692	21864	457363	102362	468168	40
21	21388	97686	21895	456726	102369	467546	39
22	21417	97680	21925	456091	102375	466925	38
23	21445	97673	21956	455458	102382	466307	37
24	21474	97667	21986	454826	102388	465690	36
25	21502	97661	22017	454196	102395	465074	35
26	21530	97655	22047	453568	102402	464461	34
27	21559	97649	22078	452941	102408	463849	33
28	21587	97642	22108	452316	102415	463238	32
29	21616	97636	22139	451693	102421	462630	31
30	21644	97630	22169	451071	102428	462023	30

A TABLE OF

12	Sines		Tangents		Secants		
31	21672	97623	22200	450451	102435	461417	29
32	21701	97617	22231	449832	102441	460813	28
33	21729	97611	22261	449215	102458	460211	27
34	21758	97604	22292	448600	102454	459611	26
35	21786	97598	22322	447986	102461	459012	25
36	21814	97592	22353	447374	102468	458414	24
37	21843	97585	22383	446764	102474	457819	23
38	21871	97579	22414	446155	102481	457224	22
39	21899	97573	22443	445547	102488	456632	21
40	21928	97566	22475	444942	102494	456041	20
41	21956	97560	22505	444338	102501	455451	19
42	21985	97553	22536	443735	102508	454863	18
43	22013	97547	22567	443134	102515	454277	17
44	22041	97541	22597	442534	102521	453692	16
45	22070	97534	22628	441936	102528	453109	15
46	22098	97528	22658	441340	102535	452527	14
47	22126	97521	22689	440745	102542	451947	13
48	22155	97515	22719	440152	102548	451368	12
49	22183	97508	22750	439560	102555	450791	11
50	22212	97502	22781	438969	102562	450216	10
51	22240	97496	22811	438381	102569	449642	9
52	22268	97489	22842	437793	102576	449069	8
53	22297	97483	22872	437207	102582	448498	7
54	22325	97476	22903	436623	102589	447928	6
55	22353	97470	22934	436040	102596	447360	5
56	22382	97363	22964	435459	102603	446793	4
57	22410	97457	22995	434879	102610	446228	3
58	22438	97450	23026	434300	102617	445664	2
59	22467	97444	23056	433723	102624	445102	1
60	22495	97437	23087	433147	102630	444541	0

A TABLE OF

13

Sines

Tangents

Secants

1	22523	97430	23117	432573	102637	443982	59
2	22552	97424	23148	432001	102644	443424	58
3	22580	97417	23179	431429	102651	442867	57
4	22608	97411	23209	430860	102658	442312	56
5	22637	97404	23240	430291	102665	441758	55
6	22665	97398	23271	429724	102672	441206	54
7	22693	97391	23301	429159	102679	440655	53
8	22722	97384	23332	428594	102686	440106	52
9	22750	97378	23363	428032	102693	439558	51
10	22778	97371	23393	427471	102700	439012	50
11	22807	97365	23424	426911	102707	438466	49
12	22835	97358	23455	426352	102714	437923	48
13	22863	97351	23485	425795	102721	437380	47
14	22892	97345	23516	425239	102728	436839	46
15	22920	97338	23547	424685	102735	436300	45
16	22948	97331	23578	424132	102742	435761	44
17	22977	97325	23608	423580	102749	435224	43
18	23005	97318	23639	423030	102756	434689	42
19	23033	97311	23670	422481	102763	434155	41
20	23062	97304	23700	421933	102770	433622	40
21	23089	97298	23731	421387	102777	433090	39
22	23118	97291	23762	420842	102784	432560	38
23	23146	97284	23793	420298	102791	432031	37
24	23175	97278	23823	419756	102799	431503	36
25	23203	97271	23854	419215	102806	430977	35
26	23231	97264	23885	418675	102813	430452	34
27	23260	97257	23916	418137	102820	429929	33
28	23288	97251	23944	417600	102827	429406	32
29	23316	97244	23977	417064	102834	428885	31
30	23345	97237	24008	416530	102842	428366	30

TABLE OF

13	Sines		Tangents		Secants		
31	23373	97230	24039	415997	102849	427847	29
32	23401	97222	24069	415465	102856	427330	28
33	23429	97217	24100	414937	102863	426814	27
34	23458	97210	24131	414405	102870	426300	26
35	23486	97203	24162	413877	102878	425786	25
36	23514	97196	24193	413350	102885	425274	24
37	23542	97189	24223	412825	102892	424764	23
38	23571	97182	24254	412301	102899	424254	22
39	23599	97176	24285	411778	102907	423746	21
40	23627	97169	24316	411256	102914	423239	20
41	23656	97162	24347	410736	102921	422734	19
42	23684	97155	24377	410217	102928	422229	18
43	23712	97148	24408	409699	102936	421726	17
44	23740	97141	24439	409182	102943	421224	16
45	23769	97134	24470	408667	102950	420724	15
46	23797	97127	24501	408152	102958	420224	14
47	23825	97120	24531	407639	102965	419726	13
48	23853	97113	24562	407127	102972	419229	12
49	23882	97106	24593	406617	102980	418733	11
50	23910	97100	24624	406107	102987	418238	10
51	23938	97093	24655	405599	102994	417744	9
52	23966	97086	24686	405092	103002	417252	8
53	23995	97079	24717	404586	103009	416761	7
54	24023	97072	24747	404081	103017	416271	6
55	24051	97065	24778	403578	103024	415782	5
56	24079	97058	24809	403076	103032	415295	4
57	24108	97051	24840	402574	103039	414809	3
58	24136	97044	24871	402074	103046	414323	2
59	24164	97037	24902	401576	103054	413839	1
60	24192	97030	24933	401078	103061	413357	0

A TABLE OF

14	Sines		Tangents		Secants		
1	24220	97023	24964	400581	103069	412874	59
2	24249	97015	24995	400086	103076	412394	58
3	24277	97008	25026	399592	103084	411915	57
4	24305	97001	25056	399099	103091	411437	56
5	24333	96994	25087	398607	103099	410960	55
6	24361	96987	25118	398117	103106	410484	54
7	24390	96980	25149	397627	103114	410009	53
8	24418	96973	25180	397139	103121	409535	52
9	24446	96966	25211	396651	103129	409063	51
10	24474	96959	25242	396165	103137	408591	50
11	24503	96952	25273	395680	103144	408121	49
12	24531	96945	25304	395196	103152	407652	48
13	24559	96937	25335	394713	103159	407184	47
14	24587	96930	25366	394232	103167	406717	46
15	24615	96923	25397	393751	103175	406251	45
16	24644	96916	25428	393271	103182	405786	44
17	24672	96909	25459	392792	103190	405322	43
18	24700	96902	25490	392316	103197	404860	42
19	34728	96894	25521	391839	103206	404398	41
20	24756	96887	25552	391364	103213	403938	40
21	24784	96880	25583	390890	103220	403479	39
22	24813	96874	25614	390417	103228	403020	38
23	24841	96866	25645	389945	103236	402563	37
24	24869	96858	25676	389474	103244	402107	36
25	24897	96851	25607	389004	103251	401652	35
26	24925	96844	25738	388536	103259	401198	34
27	24954	96837	25769	388068	103267	400745	33
28	24982	96829	25800	387601	103275	400293	32
29	25010	96822	35831	387136	103281	399843	31
30	25038	96815	25862	386671	103290	399393	30

A TABLE OF

14

Sines

Tangents

Secants

31	25066	96807	25893	386208	103298	398944	29
32	25094	96800	25924	385745	103306	398496	28
33	25122	96793	25955	385284	103313	398050	27
34	25151	96786	25986	384823	103321	397605	26
35	25179	96778	26017	384364	103329	397160	25
36	25207	96771	26048	383909	103337	396716	24
37	25235	96764	26079	383449	103345	396274	23
38	25263	96756	26110	382992	103353	395832	22
39	25291	96749	26141	382537	103360	395392	21
40	25320	96742	26172	382083	103368	394952	20
41	25348	96734	26203	381630	103376	394514	19
42	25376	96727	26235	381177	103384	394076	18
43	25404	96719	26266	380726	103392	393640	17
44	25432	96712	26297	380276	103400	393204	16
45	25460	96705	26328	379827	103408	392770	15
46	25488	96699	26359	379378	103416	392337	14
47	25516	96690	26390	378931	103423	391904	13
48	25545	96682	26421	378484	103432	391473	12
49	25573	96675	26452	378039	103439	391042	11
50	25601	96667	26483	377595	103447	390612	10
51	25629	96660	26515	377152	103455	380184	9
52	25657	96653	26545	376709	103463	389756	8
53	25685	96645	26577	376268	103471	389330	7
54	25713	96638	26608	375828	103479	388904	6
55	25741	96630	26639	375388	103487	388479	5
56	25769	96623	26670	374950	103495	388056	4
57	25798	96615	26701	374512	103503	387633	3
58	25826	96608	26733	374076	103512	387211	2
59	25854	96600	26764	373640	103520	386790	1
60	25882	96593	26795	373205	103528	386370	0

A TABLE OF

15	Sines		Tangents		Secants		
1	25910	96585	26826	372771	103536	385951	59
2	25938	96578	26857	372339	103544	385533	58
3	25966	96570	26888	371907	103552	385116	57
4	25994	96562	26920	371476	103560	384700	56
5	26022	96555	26951	371046	103568	384285	55
6	26050	96547	26982	370617	103576	383871	54
7	26079	96540	27013	370188	103584	383457	53
8	26107	96532	27044	369761	103592	383045	52
9	26135	96524	27076	369335	103601	382633	51
10	26163	96517	27107	368909	103609	382223	50
11	26191	96509	27138	368485	103617	381813	49
12	26219	96502	27169	368061	103625	381404	48
13	26247	96494	27201	367638	103633	380996	47
14	26275	96486	27232	367217	103642	380589	46
15	26303	96479	27263	366796	103650	380183	45
16	26331	96471	27294	366376	103658	379778	44
17	26359	96463	27326	365957	103666	379371	43
18	26387	96456	27357	365538	103674	378970	42
19	26415	96448	27388	365121	103683	378568	41
20	26443	96440	27419	364705	103691	378166	40
21	26471	96433	27451	364289	103699	377765	39
22	26500	96425	27482	363874	103708	377364	38
23	26528	96417	27513	363461	103716	376966	37
24	26556	96410	27545	363048	103724	376568	36
25	26584	96402	27576	362636	103732	376171	35
26	26612	96394	27607	362225	103741	375775	34
27	26640	96386	27639	361814	103749	375379	33
28	26668	96379	27670	361405	103757	374985	32
29	26696	96371	27701	360996	103766	374591	31
30	26724	96363	27732	360588	103774	374198	30

A TABLE OF

15

Sines

Tangents

Secants

31	26752	96355	27764	369182	103783	373806	29
32	26780	96347	27795	359775	103791	373415	28
33	26808	96340	27826	359370	103799	373024	27
34	26836	96332	27858	358966	103808	372635	26
35	26864	96324	27889	358562	103816	372246	25
36	26892	96316	27920	358160	103825	371858	24
37	26920	96308	27952	357758	103832	371471	23
38	26948	96301	27983	357357	103843	371085	22
39	26976	96293	28015	356957	103850	370699	21
40	27004	96285	28046	356557	103858	370315	20
41	27032	96277	28077	356159	103867	369931	19
42	27060	96269	28109	355761	103875	369548	18
43	27088	96261	28140	355364	103884	369166	17
44	27116	96253	28172	354968	103892	368785	16
45	27144	96246	28203	354573	103901	368405	15
46	27172	96238	28234	354179	103909	368025	14
47	27200	96230	28266	353785	103918	367647	13
48	27228	96222	28297	353393	103927	367269	12
49	27256	96214	28329	353001	103935	366892	11
50	27284	96206	28360	352609	103944	366515	10
51	27312	96198	28391	352219	103952	366140	9
52	27340	96190	28423	351830	103961	365765	8
53	27368	96182	28454	351441	103969	365391	7
54	27396	96174	28486	351053	103978	365018	6
55	27424	96166	28517	350666	103987	364646	5
56	27452	96158	28549	350279	103995	364274	4
57	27480	96150	28580	449894	104004	363903	3
58	27508	96142	28612	349509	104013	363533	2
59	27536	96134	28643	349125	104021	363164	1
60	27564	96126	28675	348742	104030	362796	0

E

74

A TABLE OF

16	Sines		Tangents		Secants		
1	27592	96118	28706	348359	104039	362428	59
2	27620	96110	28737	347977	104047	362061	58
3	27648	96102	28769	347590	104056	361693	57
4	27676	96994	28800	347216	104065	361330	56
5	27704	96086	28832	346837	104073	360965	55
6	27731	96078	28863	346458	104082	360601	54
7	27760	96070	28895	346080	104091	360238	53
8	27787	96062	28927	345703	104100	359876	52
9	27815	96054	28958	345327	104108	359515	51
10	27843	96046	28990	344951	104117	359154	50
11	27871	96037	29021	344576	104126	358794	49
12	27899	96029	29053	344202	104135	358435	48
13	27927	96021	29084	343829	104144	358076	47
14	27955	96013	29116	343456	104152	357718	46
15	27983	96005	29147	343085	104161	357361	45
16	28011	95997	29179	342713	104170	357005	44
17	28039	95989	29210	342343	104179	356649	43
18	28067	95981	29242	341973	104188	356295	42
19	28095	95972	29274	341605	104197	355941	41
20	28123	95964	29305	341236	104206	355587	40
21	28150	95956	29337	340869	104214	355235	39
22	28178	95948	29368	340502	104223	354883	38
23	28206	95940	29400	340136	104232	354532	37
24	28234	95931	29432	339771	104241	354181	36
25	28262	95923	29463	339406	104250	353831	35
26	28290	95915	29495	339043	104259	353482	34
27	28318	95907	29526	338679	104268	353134	33
28	28346	95898	29558	338317	104277	352787	32
29	28374	95890	29590	337955	104286	352440	31
30	28401	95882	29621	337594	104295	352092	30

A TABLE OF

16

Sines

Tangents

Secants

31	28429	95874	29653	337234	104304	351748	29
32	28457	95865	29685	336875	104313	351404	28
33	28485	95857	29716	336516	104322	351060	27
34	28513	95849	29748	336157	104331	350716	26
35	28541	95841	29780	335800	104340	350374	25
36	28569	95832	29811	335443	104349	350032	24
37	28597	95824	29843	335087	104358	349691	23
38	28625	95816	29875	334732	104367	349350	22
39	28652	95807	29906	334377	104376	349010	21
40	28680	95799	29938	334023	104385	348671	20
41	28708	95791	29970	333670	104394	348333	19
42	28736	95782	30001	333317	104403	347995	18
43	28764	95774	30033	332965	104413	347658	17
44	28792	95766	30065	332614	104422	347321	16
45	28820	95757	30097	332264	104431	346986	15
46	28847	95749	30128	331914	104440	346651	14
47	28875	95740	30160	331564	104449	346316	13
48	28903	95732	30192	331216	104458	345983	12
49	28931	95724	30224	330868	104467	345650	11
50	28959	95715	30255	330521	104477	345317	10
51	28987	95707	30287	330174	104486	344986	9
52	29015	95698	30319	329828	104495	344655	8
53	29042	95690	30351	329483	104504	344324	7
54	29070	95681	30382	329139	104514	343995	6
55	29098	95673	30414	328795	104523	343666	5
56	29126	95664	30446	328452	104532	343337	4
57	29154	95656	30478	328109	104541	343009	3
58	29182	95648	30509	327767	104551	342682	2
59	29209	95639	30541	327426	104560	342356	1
60	29237	95630	30573	327085	104569	342030	0

E 2

73

A TABLE OF

	Sines		Tangents		Secants		
17							
1	29265	95622	30605	326745	104578	341705	59
2	29293	95613	30637	326406	104588	341381	58
3	29321	95605	30669	326067	104597	341057	57
4	29348	95596	30700	325729	104606	340734	56
5	29376	95588	30732	325392	104616	340411	55
6	29404	95579	30764	325055	104625	340089	54
7	29432	95571	30796	324719	104635	339768	53
8	29460	95562	30828	324383	104644	339448	52
9	29487	95554	30860	324049	104653	339128	51
10	29515	95545	30891	323714	104663	338808	50
11	29543	95536	30923	323381	104672	338489	49
12	29571	95528	30955	323048	104682	338171	48
13	29599	95519	30987	322715	104691	337854	47
14	29629	95511	31019	322383	104700	337537	46
15	29654	95502	31051	322052	104710	337221	45
16	29682	95493	31083	321722	104719	336905	44
17	29710	95485	31115	321392	104729	336590	43
18	29737	95476	31147	321063	104738	336276	42
19	29765	95467	31178	320734	104748	335962	41
20	29793	95459	31210	320406	104757	335649	40
21	29821	95450	31242	320079	104767	335336	39
22	29849	95441	31274	319752	104776	335024	38
23	29876	95433	31306	319426	104786	334713	37
24	29904	95424	31338	319100	104795	334402	36
25	29932	95415	31370	318775	104805	334092	35
26	29960	95407	31402	318451	104815	333783	34
27	29987	94398	31435	318127	104825	333474	33
28	30015	95389	31466	317804	104834	333166	32
29	30043	95380	31498	317481	104843	332858	31
30	30071	95372	31520	317159	104853	332551	30

TABLE OF

17

	Sines		Tangents		Secants		
31	30098	95363	31562	316838	104863	332244	29
32	30126	95354	31594	316517	104872	331939	28
33	30154	95345	31626	316197	104882	331633	27
34	30182	95337	31658	315877	104891	331328	26
35	30209	95328	31690	315558	104901	331024	25
36	30237	95319	31722	315240	104911	330721	24
37	30265	95310	31754	314922	104920	330418	23
38	30292	95301	31786	314605	104930	330115	22
39	30330	95293	31818	314288	104940	339814	21
40	30348	95284	31850	313972	104950	329512	20
41	30376	95275	31882	313656	104959	329212	19
42	30403	95266	31914	313341	104969	328912	18
43	30431	95257	31946	313027	104979	328612	17
44	30459	95248	31978	312713	104989	328313	16
45	30486	95240	32010	312400	104998	328015	15
46	30514	95231	32042	312087	105008	327717	14
47	30542	95222	32074	311775	105018	327420	13
48	30570	95213	32106	311464	105028	327125	12
49	30597	95204	32139	311153	105038	326827	11
50	30625	95195	32171	310842	105047	326531	10
51	30652	95186	32203	310532	105057	326237	9
52	30680	95177	32235	310223	105067	325942	8
53	30708	95168	32267	309914	105077	325648	7
54	30736	95176	32299	309806	105087	325355	6
55	30763	95150	32331	309298	105097	325062	5
56	30791	95142	32363	308991	105107	324770	4
57	30819	95133	32396	308685	105116	324478	3
58	30846	95124	32427	308379	105126	324187	2
59	30874	95115	32460	308073	105136	323897	1
60	30902	95106	32492	307768	105146	323607	0

E 3

72

A TABLE OF

18

	Sines		Tangents		Secants		
1	30929	95097	32524	307464	105156	323317	59
2	30957	95088	32556	307160	105166	323028	58
3	30985	95079	22588	306857	105176	322740	57
4	31012	95070	32621	306554	105186	322452	56
5	31040	95061	32653	306252	105196	322165	55
6	31068	95052	32685	305950	105206	321878	54
7	31095	95043	32717	305649	105216	321592	53
8	31123	95033	32749	305349	105226	321306	52
9	31151	95024	32782	305049	105236	321021	51
10	31178	95013	32814	304749	105246	320737	50
11	31206	95006	32846	304450	105256	320453	49
12	31233	94997	32878	304152	105266	320169	48
13	31261	94988	32911	303854	105277	319886	47
14	31289	94979	32943	303556	105286	319604	46
15	31316	94970	32975	303259	105297	319322	45
16	31344	94961	33007	302963	105307	319040	44
17	31372	94952	33040	302667	105317	318759	43
18	31399	94943	33072	302372	105327	318479	42
19	31427	94933	33104	302077	105337	318199	41
20	31454	94924	33136	301783	105347	317920	40
21	31482	94915	33169	301489	105357	317641	39
22	31510	94906	33201	301196	105367	317363	38
23	31537	94897	33233	300906	105378	317085	37
24	31565	94888	33266	300611	105388	316808	36
25	31593	94878	33298	300319	105398	316531	35
26	31620	94869	33330	300028	105408	316255	34
27	31644	94860	33363	299738	105418	315979	33
28	31675	94851	33395	299447	105429	315703	32
29	31703	94842	33427	299158	105439	315429	31
30	31730	94832	33460	298868	105449	315154	30

A TABLE OF

18

Sines

Tangents

Secants

31	31758	94823	33492	298580	105459	314881	29
32	31785	94814	33524	298292	105470	314607	28
33	31813	94805	33557	298004	105480	314335	27
34	31841	94795	33589	297717	105490	314062	26
35	31868	94786	33621	297430	105501	313791	25
36	31896	94777	33654	297144	105511	313519	24
37	31924	94768	33686	296858	105521	313249	23
38	31951	94758	33719	296573	105532	312978	22
39	31979	94749	33751	296288	105542	312709	21
40	32006	94740	33783	296004	105552	312439	20
41	32034	94730	33816	295720	105563	312170	19
42	32061	94721	33848	295437	105573	311902	18
43	32089	94712	33881	295154	105584	311635	17
44	32116	94702	33914	294872	105594	311367	16
45	32144	94693	33945	294590	105604	311100	15
46	32171	94684	33978	294309	105615	310834	14
47	32199	94674	34010	294028	105625	310568	13
48	32227	94665	34043	293748	105636	310303	12
49	32254	94656	34075	293468	105646	310038	11
50	32282	94646	34108	293189	105657	309773	10
51	32309	94637	34140	292910	105657	309510	9
52	32337	94627	34173	292631	105678	309246	8
53	32364	94618	34205	292353	105688	308983	7
54	32392	94609	34238	292076	105699	308721	6
55	32419	94599	34270	291799	105709	308458	5
56	32447	94590	34303	291522	105720	308197	4
57	32474	94581	34335	291246	105730	307936	3
58	32502	94571	34368	290971	105741	307675	2
59	32529	94561	34400	290696	105751	307415	1
60	32557	94552	34433	290421	105762	307155	0

A TABLE OF

19

Sines

Tangents

Secants

1	32584	94542	34465	290147	105773	306896	59
2	32612	94533	34498	289873	105783	306637	58
3	32639	94523	34530	289600	105794	306379	57
4	32667	94514	34563	289327	105805	306121	56
5	32694	94504	34596	289055	105815	305864	55
6	32722	94495	34628	288783	105826	305607	54
7	32749	94485	34661	288511	105836	305350	53
8	32777	94476	34693	288240	105847	305094	52
9	32804	94466	34726	287970	105858	304839	51
10	32832	94457	34758	287700	105869	304584	50
11	32859	94447	34791	287430	105879	304329	49
12	32887	94438	34824	287161	105890	304075	48
13	32914	94428	34856	286892	105901	303821	47
14	32942	94418	34889	286624	105911	303568	46
15	32969	94409	34922	286356	105922	303315	45
16	32997	94399	34954	286089	105933	303062	44
17	33024	94390	34987	285822	105944	302810	43
18	33051	94380	35019	285555	105955	302559	42
19	33079	94370	35052	285289	105965	302308	41
20	33106	94361	35085	285023	105976	302057	40
21	33134	94351	35117	284758	105987	301807	39
22	33161	94342	35150	284494	105998	301557	38
23	33189	94332	35183	284229	106009	301308	37
24	33216	94322	35216	283965	106019	301059	36
25	33244	94313	35248	283702	106030	300810	35
26	33271	94303	35281	283439	106041	300562	34
27	33298	94293	35314	283176	106052	300315	33
28	33326	94284	35356	282915	106063	300067	32
29	33353	94274	35379	282653	106074	299821	31
30	33381	94264	35412	282391	106085	299574	30

A TABLE OF

19

Sines

Tangents

Secants

31	33408	94254	35445	282130	106096	299328	29
32	33436	94245	35477	281870	106107	299083	28
33	33463	94235	35510	281610	106118	298837	27
34	33490	94225	35543	281350	106129	298593	26
35	33518	94216	35576	281091	106140	298349	25
36	33545	94206	35608	280833	106151	298106	24
37	33573	94196	35641	280574	106162	297862	23
38	33600	94186	35674	280316	106173	297619	22
39	33627	94176	35707	280059	106184	297377	21
40	33655	94167	35740	279802	106195	297135	20
41	33682	94157	35772	279545	106206	296893	19
42	33710	94147	35805	279289	106217	296652	18
43	33737	94137	35838	279033	106228	296411	17
44	33764	94127	35871	278778	106239	296171	16
45	33792	94118	35904	278523	106250	295931	15
46	33819	94108	35937	278269	106261	295691	14
47	33846	94098	35969	278014	106272	295452	13
48	33874	94088	36002	277761	106283	295213	12
49	33901	94077	36035	277507	106295	294975	11
50	33929	94068	36068	277255	106306	294737	10
51	33956	94058	36101	277002	106317	294500	9
52	33983	94049	36134	276750	106328	294263	8
53	34011	94039	36167	276498	106339	294026	7
54	34038	94029	36199	276247	106350	293790	6
55	34065	94019	36232	275996	106362	293554	5
56	34093	94009	36265	275746	106373	293318	4
57	34120	93999	36298	275496	106384	293083	3
58	34147	93989	36331	275246	106395	292849	2
59	34175	93979	36364	274997	106407	292614	1
60	34202	93969	36397	274748	106418	292380	0

F

70

A TABLE OF

20

	Sines		Tangents		Sec ants		
1	34229	93939	36430	274499	106429	292147	59
2	34257	93949	36463	274251	106440	291914	58
3	34284	93939	36496	274004	106452	291681	57
4	34311	93929	36529	273756	106463	291449	56
5	34339	93919	36562	273509	106474	291217	55
6	34367	93909	36595	273263	106486	290986	54
7	34393	93899	36628	273017	106497	290754	53
8	34421	93889	36661	272771	106508	290524	52
9	34448	93879	36694	272526	106520	290293	51
10	34475	93869	36727	272281	106531	290063	50
11	34503	93859	36760	272036	106542	289834	49
12	34530	93849	36793	271792	106554	289605	48
13	34557	93839	36826	271548	106565	289376	47
14	34584	93829	36859	271305	106577	289148	46
15	34612	93819	36892	271062	106588	288920	45
16	34639	93809	36925	270819	106600	288692	44
17	34666	93799	36958	270577	106611	288465	43
18	34694	93789	36991	270335	106612	288238	42
19	34721	93779	37024	270094	106634	288011	41
20	34748	93769	37057	269853	106645	287785	40
21	34775	93759	37090	269612	106657	287560	39
22	34803	93748	37123	269371	106668	287334	38
23	34830	93738	37157	269131	106680	287109	37
24	34857	93728	37190	268892	106691	286885	36
25	34885	93718	37223	268653	106703	286661	35
26	34912	93708	37256	268414	106715	286437	34
27	34939	93698	37289	268175	106726	286213	33
28	34966	93688	37322	267937	106738	285990	32
29	34993	93677	37355	267700	106749	285767	31
30	35021	93667	37388	267462	106761	285545	30

A TABLE OF

20

	Sines		Tangents		Secants		
31	35048	93657	37422	267225	106771	285323	29
32	35075	93647	37455	266989	106784	285102	28
33	35102	93637	37488	266752	105796	284880	27
34	35130	93626	37521	266516	106807	284659	26
35	35157	93616	37554	266281	106819	284439	25
36	35184	93606	37588	266049	106831	284219	24
37	35211	93596	37621	265811	106842	283999	23
38	35239	93585	37654	265576	106854	283780	22
39	35266	93575	37687	265342	106866	283561	21
40	35293	93565	37720	265109	106878	283342	20
41	35320	93555	37754	264875	106889	283124	19
42	35347	93544	37787	264642	106901	282906	18
43	35375	93534	37820	264410	106913	282688	17
44	35402	93524	37853	264177	106925	282471	16
45	35429	93514	37887	263945	106936	282254	15
46	35456	93503	37920	263714	106948	282037	14
47	35483	93493	37953	263483	106960	281821	13
48	35511	93483	37986	263252	106972	281605	12
49	35538	93472	38020	263021	106984	281390	11
50	35565	93462	38053	262791	106995	281175	10
51	35592	93452	38086	262561	107007	280960	9
52	35619	93441	38120	262332	107019	280746	8
53	35647	93431	38153	262103	107031	280531	7
54	35674	93420	38180	261874	107043	280318	6
55	35710	93410	38220	261646	107055	280104	5
56	35728	93400	38253	261418	107067	279891	4
57	35755	93389	38286	261190	107079	279679	3
58	35782	93379	38320	260963	107091	279466	2
59	35810	93368	38353	260736	107103	279254	1
60	35837	93358	38386	260509	107114	279043	0

F 2

69

A TABLE OF

21

	Sines		Tangents		Secants		
1	35864	93348	38420	260283	107126	278832	59
2	35891	93337	38453	260057	107139	278621	58
3	35918	93327	38487	259831	107150	278410	57
4	35945	93316	38520	259606	107162	278200	56
5	35973	93306	38553	259381	107174	277990	55
6	36000	93295	38587	259156	107186	277780	54
7	36027	93285	38620	258932	107198	277571	53
8	36054	93274	38654	258708	107211	277362	52
9	36081	93264	38687	258484	107223	277154	51
10	36108	93253	38721	258261	107235	276945	50
11	36135	93243	38754	258038	107247	276737	49
12	36162	93232	38787	257815	107259	276530	48
13	36190	93222	38821	257593	107271	276323	47
14	36217	93211	38854	257371	107283	276116	46
15	36244	93201	38888	257150	107295	275909	45
16	36271	93191	38921	256928	107307	275703	44
17	36298	93180	38955	256707	107320	275497	43
18	36325	93169	38988	256487	107332	275292	42
19	36352	93159	39022	256266	107344	275086	41
20	36379	93148	39055	256047	107356	274881	40
21	36406	93137	39089	255827	107368	274677	39
22	36434	93127	39122	255608	107380	274473	38
23	36461	93116	39156	255389	107393	274269	37
24	36488	93106	39190	255170	107405	274065	36
25	36515	93095	39223	254952	107417	273863	35
26	36542	93084	39257	254734	107429	273659	34
27	36569	93074	39290	254516	107442	273456	33
28	36596	93063	39324	254299	107454	273254	32
29	36623	93052	39357	254082	107466	273052	31
30	36650	93042	39391	253864	107479	272850	30

A TABLE OF

21

	Sines		Tangents		Secants		
31	36677	93031	39425	253648	107491	272649	29
32	36704	93020	39458	253432	107503	272448	28
33	36731	93010	39492	253217	107516	272247	27
34	36658	92999	39526	253001	107528	272047	26
35	36785	92988	39559	252786	107540	271847	25
36	36812	92978	39593	252571	107553	271647	24
37	36840	92967	39626	252357	107565	271448	23
38	36867	92956	39660	252142	107578	271249	22
39	36894	92946	39694	251929	107590	271050	21
40	36921	92935	39727	251715	107602	270851	20
41	36948	92924	39761	251502	107615	270653	19
42	36975	92913	39795	251289	107627	270455	18
43	37002	92903	49829	251076	107640	270258	17
44	37029	92892	39862	250864	107652	270061	16
45	37056	92881	39896	250652	107665	269864	15
46	37083	92870	39930	250440	107677	269667	14
47	37110	92859	39963	250229	107690	269471	13
48	37137	92849	39997	250018	107702	269275	12
49	37164	92838	40031	249807	107715	269079	11
50	37191	92827	40065	249597	107727	268884	10
51	37218	92816	40098	249386	107740	268689	9
52	37245	92805	40132	249177	107752	268494	8
53	37272	92794	40166	248967	107765	268299	7
54	37299	92784	40200	248758	107778	268105	6
55	37326	92773	40234	248549	107790	267911	5
56	37353	92762	40267	248340	107803	267718	4
57	37380	92751	40301	248132	107815	267524	3
58	37407	92740	40335	247924	107828	267332	2
59	37434	92729	40369	247716	107841	267139	1
60	37461	92718	40403	247509	107853	266947	0

F 3

68

A TABLE OF

22

	Sines		Tangents		Secants		
1	37488	92707	40436	247302	107866	266755	59
2	37515	92697	40470	247095	107879	266563	58
3	37542	92686	40504	246888	107892	266371	57
4	37569	92675	40538	246682	107903	266180	56
5	37595	92664	40572	246476	107917	265989	55
6	37622	92653	40606	246270	107930	265799	54
7	37649	92642	40640	246065	107942	265609	53
8	37676	92631	40674	245860	107955	265419	52
9	37703	92620	40707	245655	107968	265229	51
10	37730	92609	40741	245451	107981	265040	50
11	37757	92598	40775	245246	107994	264851	49
12	37784	92587	40809	245043	108006	264662	48
13	37811	92576	40843	244839	108019	264473	47
14	37838	92565	40877	244636	108032	264285	46
15	37865	92554	40911	244433	108045	264097	45
16	37892	92543	40945	244230	108058	263909	44
17	37919	92532	40979	244027	108071	263722	43
18	37946	92521	41013	243825	108084	263535	42
19	37973	92510	41047	243623	108096	263348	41
20	37999	92499	41081	243422	108109	263162	40
21	38027	92488	41115	243220	108122	262976	39
22	38053	92477	41149	243019	108135	262790	38
23	38080	92466	41183	242819	108148	262604	37
24	38107	92455	41217	242618	108161	262419	36
25	38134	92444	41251	242418	108174	262234	35
26	38161	92432	41285	242218	108187	262049	34
27	38188	92421	41319	242018	108200	261864	33
28	38215	92410	41353	241819	108213	261680	32
29	38241	92399	41387	241620	108226	261496	31
30	38268	92388	41421	241421	108239	261313	30

A TABLE OF

22

Sines

Tangents

Secants

31	38295	92377	41455	241223	108252	261129	29
32	38322	92356	41490	241025	108265	268946	28
33	38349	92355	41524	240827	108278	260763	27
34	38376	92343	41558	240629	108291	260581	26
35	38403	92332	41592	240432	108305	260399	25
36	38430	92321	41626	240635	108318	260417	24
37	38456	92310	41660	240038	108331	260035	23
38	38483	92299	41694	239841	108344	259853	22
39	38510	92287	41728	239645	108357	259672	21
40	38537	92276	41763	239449	108370	259491	20
41	38564	92265	41767	239253	108383	259311	19
42	38591	92254	41831	239058	108370	259130	18
43	38677	92243	41865	238862	108410	258950	17
44	38644	92231	41899	238668	108423	258771	16
45	38671	92220	41933	238473	108436	258591	15
46	38698	92209	41968	238279	108449	258412	14
47	38725	92197	42002	238084	108463	258233	13
48	38752	92186	42036	237891	108476	258054	12
49	38778	92175	42070	237697	108489	257876	11
50	38805	92164	42105	237504	108503	257698	10
51	38832	92152	42139	237311	108516	257520	9
52	38859	92141	42173	237118	108529	257342	8
53	38886	92130	42207	236925	108542	257165	7
54	38912	92119	42242	236733	108556	256988	6
55	38939	92107	42276	236541	108569	256811	5
56	38966	92096	42310	236349	108582	256634	4
57	38993	92085	43345	236158	108596	256458	3
58	39020	92073	42379	235967	108609	256282	2
59	39046	92062	42423	235776	108623	256106	1
60	39073	92050	42447	235585	108635	255920	0

A TABLE OF

23	Sines		Tangents		Secants		
1	39100	92039	42482	235395	108649	255755	59
2	39117	92028	42516	235205	108663	255580	58
3	39153	92016	42551	235015	108676	255406	57
4	39180	91005	41585	234825	108690	255230	56
5	39207	91994	42619	234636	108703	255057	55
6	29234	91982	42654	214447	108717	254883	54
7	39260	91971	42688	234258	108730	254709	53
8	39287	91959	42722	234069	108744	254536	52
9	39314	91948	42757	233881	108756	254362	51
10	39341	91936	42791	233693	108771	254190	50
11	39367	91925	42826	233505	108784	254017	49
12	39394	91914	42860	233317	108798	253844	48
13	39421	91902	42894	233130	108811	253672	47
14	39448	91891	42929	232943	108825	253500	46
15	39474	91879	42963	232756	108839	253329	45
16	39501	91868	42998	232570	108852	253157	44
17	39528	91856	43032	232383	108866	252986	43
18	39555	91845	43067	232197	108880	252815	42
19	39581	91833	43101	232012	108893	252645	41
20	39608	91822	43136	231826	108907	252474	40
21	39635	91810	43170	231641	108921	252304	39
22	39661	91799	43205	231456	108934	252134	38
23	39688	91787	43239	231271	108948	251965	37
24	39715	91775	43274	231086	108962	251795	36
25	39741	91764	43308	230902	108975	251626	35
26	39768	91752	43343	230718	108989	251457	34
27	39795	91741	43378	230534	109003	251289	33
28	39822	91729	43412	230351	109017	251120	32
29	39848	91718	43447	230167	109030	250952	31
30	39875	91706	43481	229984	109044	250784	30

A TABLE OF

23

Sines

Tangents

Secants

31	39902	91694	43516	229801	109058	250617	29
32	39928	91683	43550	229619	109072	250449	28
33	39955	91671	43585	229437	109086	250282	27
34	39982	91660	43620	229254	109099	250115	26
35	40008	91648	43654	229073	109113	249948	25
36	40035	91636	43689	228891	109127	249782	24
37	40062	91625	43724	228791	109141	249616	23
38	40088	91613	43758	228528	109155	249450	22
39	40115	91601	43793	228348	109169	249284	21
40	40141	91590	43828	228167	109183	249119	20
41	40168	91578	43862	227987	109197	248954	19
42	40195	91566	43897	227806	109211	248789	18
43	40221	91555	43932	227626	109224	248624	17
44	40248	91543	43966	227447	109238	248459	16
45	40275	91531	44001	227267	109252	248295	15
46	40301	91519	44036	227088	109266	248131	14
47	40328	91508	44071	226909	109280	247967	13
48	40355	91496	44105	226730	109294	247804	12
49	40381	91484	44140	226552	109308	247640	11
50	40408	91472	44175	226374	109322	247477	10
51	40434	91461	44210	226196	109337	247314	9
52	40461	91449	44244	226018	109351	247152	8
53	40488	91437	44279	225840	109365	246989	7
54	40514	91425	44314	225663	109379	246827	6
55	40541	91414	44349	225486	109393	246665	5
56	40567	91402	44384	225309	109407	246504	4
57	40594	91390	44418	225132	109421	246342	3
58	40620	91378	44453	224956	109435	246181	2
59	40647	91366	44488	224780	109449	246020	1
60	40674	91355	44523	224604	109464	245859	0

G

66

A TABLE OF

24

Sines

Tangents

Secants

1	40700	91343	44558	224428	109478	245699	59
2	40727	91331	44593	224253	109492	245539	58
3	40753	91319	44627	224077	109507	245379	57
4	40780	91307	44662	223902	109520	245219	56
5	40806	91295	44697	223727	109535	245059	55
6	40833	91283	44732	223553	109549	244900	54
7	40860	91272	44767	223378	109563	244741	53
8	40886	91260	44802	223204	109577	244582	52
9	40913	91248	44837	223030	109592	244423	51
10	40939	91236	44872	222857	109606	244264	50
11	40966	91224	44907	222683	109620	244106	49
12	40992	91212	44942	222510	109635	243948	48
13	41019	91200	44977	222337	109649	243790	47
14	41045	91188	45012	222164	109663	243633	46
15	41072	91176	45047	221992	109678	243475	45
16	41098	91164	45082	221819	109692	243318	44
17	41125	91152	45117	221647	109707	243161	43
18	41151	91140	45152	221475	109721	243005	42
19	41178	91128	45187	221304	109735	242848	41
20	41204	91116	45222	221132	109750	242692	40
21	41231	91104	45257	220961	109764	242536	39
22	41257	91092	45292	220790	109779	242380	38
23	41284	91080	45327	220619	109793	242225	37
24	41310	91068	45362	220449	109808	242070	36
25	41337	91056	45397	220278	109822	241914	35
26	41363	91044	45432	220108	109837	241760	34
27	41360	91032	45497	219938	109851	241605	33
28	41416	91020	45502	219769	109866	241450	32
29	41443	91008	45537	219599	109880	241296	31
30	41469	90996	45573	219430	109895	241142	30

A TABLE OF

24

	Sines		Tangents		Secants		
31	41496	90984	45608	219261	119909	240988	29
32	41522	90972	45643	219092	109924	240835	28
33	41549	90960	45678	218923	109919	240681	27
34	41575	90948	45713	218755	109953	240528	26
35	41602	90936	45748	218587	109968	240375	25
36	41628	90924	45784	218419	109982	240222	24
37	41655	90911	45819	218251	109997	240070	23
38	41681	90899	45854	218084	110012	239918	22
39	41707	90887	45889	217916	110026	239766	21
40	41734	90875	45924	217749	110041	239614	20
41	41760	90863	45960	217582	110056	239462	19
42	41787	90851	45995	217416	110071	239311	18
43	41813	90839	46030	217249	110085	239159	17
44	41840	90826	46065	217083	110100	239008	16
45	41866	90814	46101	216918	110115	238858	15
46	41892	90802	46136	216751	110130	238707	14
47	41919	90790	46171	216585	110144	238556	13
48	41945	90778	46207	216420	110159	238406	12
49	41972	90766	46242	216255	110174	238256	11
50	41998	90753	46277	216090	110189	238106	10
51	42024	90741	46312	215925	110204	237957	9
52	42051	90729	46348	215760	110219	237808	8
53	42077	90717	46383	215596	110233	237658	7
54	42104	90704	46418	215432	110248	237509	6
55	42130	90692	46454	215268	110263	237361	5
56	42156	90680	46489	215104	110278	237212	4
57	42183	90668	46525	214940	110293	237064	3
58	42209	90655	46560	214777	110308	236916	2
59	42235	90643	46595	214614	110322	236768	1
60	42262	90631	46631	214451	110338	236621	0

G 2

65

TABLE OF

25

Sines

Tangents

Secants

1	42288	90618	46666	214283	110353	236473	59
2	42315	90606	46702	214125	110368	236325	58
3	42341	90594	46737	213963	110383	236178	57
4	42317	90582	46773	213805	110399	236031	56
5	42394	90569	46808	213639	110413	235886	55
6	42420	90557	46843	213477	110428	235738	54
7	42446	90545	46879	213316	110443	235592	53
8	42473	90532	46914	213154	110458	235446	52
9	42499	90520	26950	212993	110473	235300	51
10	42525	90507	46985	212832	110488	235154	50
11	42552	90495	47021	212671	110503	235009	49
12	42578	90483	47056	212511	110518	234863	48
13	42604	90470	47092	212350	110533	234718	47
14	42631	90458	47128	212190	110549	234574	46
15	42657	90446	47163	212030	110564	234429	45
16	42683	90433	47199	211871	110579	234284	44
17	42709	90421	47234	211711	110594	234140	43
18	42736	90408	47270	211552	110609	233996	42
19	42762	90396	47305	211392	110625	233852	41
20	42788	90383	47341	211233	110640	233708	40
21	42815	90371	47377	211075	110655	233565	39
22	42841	90358	47412	210916	110670	233421	38
23	42867	90346	47448	210758	110686	233278	37
24	42894	90334	47484	210599	110701	233135	36
25	42920	90321	47519	210441	110716	232993	35
26	42946	90309	47555	210284	110732	232850	34
27	42972	90296	47591	210126	110747	232708	33
28	42999	90284	47626	209969	110762	232566	32
29	43025	90271	47662	209811	110778	232424	31
30	43051	90259	47698	209654	110793	232282	30

TABLE OF

25

	Sines		Tangents		Secants		
31	43077	90245	47733	209498	110808	232140	29
32	43104	90233	47769	209341	110824	231999	28
33	43130	90221	47805	209184	110839	231858	27
34	43156	90208	47840	209028	110854	231717	26
35	43182	90196	47876	208872	110870	231576	25
36	43209	90183	47912	208716	110885	231436	24
37	43235	90171	47948	208560	110901	231295	23
38	43261	90158	47984	208405	110916	231155	22
39	43287	90146	48019	208250	110932	231015	21
40	43313	90133	48055	208094	110947	230875	20
41	43340	90120	48091	207939	110963	230735	19
42	43366	90108	48127	207785	110978	230596	18
43	43392	90095	48163	207630	110994	230457	17
44	43418	90082	48198	207476	111009	230317	16
45	43445	90070	48234	207321	111025	230179	15
46	43471	90057	48270	207167	111041	230040	14
47	43497	90045	48306	207014	111056	229901	13
48	43523	90032	48342	206860	111072	229763	12
49	43549	90019	48378	206705	111087	229625	11
50	43575	90007	48414	206553	111103	229487	10
51	43602	89995	48450	206400	111119	229349	9
52	43628	89981	48486	206247	111134	229211	8
53	43654	89968	48521	206094	111150	229074	7
54	43680	89956	48557	205942	111166	228937	6
55	43706	89943	48593	205789	111181	228800	5
56	43733	89930	48629	205637	111197	228663	4
57	43759	89918	48665	205485	111213	228526	3
58	43785	89905	48701	205333	111228	228390	2
59	43811	89892	48737	205182	111244	228253	1
60	43837	89879	48773	205030	111260	228117	0

A TABLE OF

26

Sines

Tangents

Secants

1	43863	89867	48809	204879	111276	227981	59
2	43883	89854	48845	204728	111292	227845	58
3	43916	89841	48881	204577	111308	227710	57
4	43942	89828	48917	204426	111323	227574	56
5	43968	89816	48953	204276	111339	227439	55
6	43994	89803	48989	204125	111355	227304	54
7	44020	89790	49026	203975	111371	227169	53
8	44046	89777	49062	203825	111387	227035	52
9	44072	89764	49098	203675	111403	226900	51
10	44098	89752	49134	203526	111419	226766	50
11	44124	89739	49170	203376	111435	226632	49
12	44151	89726	49206	203227	111451	226498	48
13	44177	89713	49242	203078	111467	226364	47
14	44203	89700	49278	202929	111483	226230	46
15	44229	89687	49315	202780	111499	226097	45
16	44255	89674	49351	202631	111515	225963	44
17	44281	89662	49387	202483	111531	225830	43
18	44307	89649	49423	202335	111547	225697	42
19	44333	89636	49459	202187	111563	225564	41
20	44359	89623	49495	202039	111579	225432	40
21	44385	89610	49532	201891	111595	225300	39
22	44411	89597	49568	201743	111611	225167	38
23	44437	89584	49604	201596	111627	225035	37
24	44464	89571	49640	201449	111643	224903	36
25	44490	89558	49677	201302	111659	224772	35
26	44516	89545	49713	201155	111675	224640	34
27	44542	89532	49749	201008	111691	224509	33
28	44568	89519	49786	200862	111708	224378	32
29	44594	89506	49822	200715	111724	224247	31
30	44620	89493	49858	200569	111740	224116	30

A TABLE OF

26

Sines

Tangents

Secants

31	44646	89480	49894	100423	111756	223984	29
32	44672	89467	49931	200277	111772	223855	28
33	44698	89454	49967	200131	111789	223724	27
34	44724	89441	50004	199986	111805	223594	26
35	44750	89428	50040	199841	111821	223464	25
36	44776	89415	50076	199695	111838	223334	24
37	44802	89402	50113	199550	111854	223205	23
38	44828	89389	50149	199405	111870	223076	22
39	44854	89376	50185	199261	111886	222946	21
40	44880	89363	50222	199116	111903	222817	20
41	44906	89350	50258	198972	111919	222688	19
42	44932	89337	50295	198828	111936	222559	18
43	44958	89324	50331	198684	111952	222430	17
44	44984	89311	50368	198540	111968	222302	16
45	45010	89298	50404	198396	111985	222174	15
46	45036	89285	50441	198253	112001	222045	14
47	45062	89272	50477	198110	112018	221918	13
48	45088	89259	50514	197966	112034	221790	12
49	45114	89245	50550	197823	112051	221662	11
50	45140	89232	50587	197680	112067	221535	10
51	45166	89219	50623	197538	112083	221407	9
52	45192	89206	50660	197395	112100	221280	8
53	45218	89193	50696	197253	112117	221153	7
54	45243	89180	50733	197111	112133	221026	6
55	45269	89167	50769	196969	112150	220900	5
56	45295	89153	50806	196827	112166	220773	4
57	45321	89140	50843	196685	112183	220647	3
58	45347	89127	50879	196545	112199	220521	2
59	45373	89114	50916	196402	112216	220395	1
60	45399	89151	50903	196261	112233	220269	0

A TABLE OF

27

	Sines		Tangents		Secants		
1	45435	89087	50989	196120	112249	220143	59
2	45451	89074	51026	195979	112266	220018	58
3	45477	89061	51063	195838	112283	219892	57
4	45503	89048	51099	195698	112299	219767	56
5	45529	89035	51136	195557	112316	219642	55
6	45554	89021	51173	195417	112333	219517	54
7	45580	89008	51209	195277	112349	219393	53
8	45606	88995	51246	195137	112367	219268	52
9	45632	88981	61283	194997	112383	219144	51
10	45658	88968	51319	194858	112400	219019	50
11	45684	88955	51356	194718	112416	218895	49
12	45710	88942	51393	194579	112433	218771	48
13	45736	88928	51430	194440	112450	218648	47
14	45762	88915	51467	194310	112467	218524	46
15	45787	88902	51503	194162	112484	218410	45
16	45813	88888	51540	194023	112501	218277	44
17	45839	88875	51577	193885	112517	218154	43
18	45865	88862	51614	193746	112534	218031	42
19	45891	88848	51651	193608	112551	217909	41
20	45917	88835	51688	193470	112568	217786	40
21	45942	88822	51724	193332	112585	217663	39
22	45968	88808	51761	193195	112602	217541	38
23	45994	88795	51798	193057	112619	217419	37
24	46020	88782	51835	192920	112636	217297	36
25	46046	88768	51272	192782	112653	217175	35
26	46072	88755	51909	192645	112670	217053	34
27	46097	88741	51946	192508	112687	216932	33
28	46123	88728	51983	192371	112704	216810	32
29	46149	88715	52020	192235	112721	216689	31
30	46175	88701	52057	192098	112738	216568	30

A TABLE OF

27

Sines

Tangents

Secants

31	46201	88688	52094	191962	112755	216447	29
32	46226	88674	52131	191826	112772	216326	28
33	46252	88661	52168	191690	112789	216206	27
34	46278	88647	52205	191554	112807	216085	26
35	46304	88634	52242	191418	112824	215965	25
36	46330	88620	52279	191282	112841	215845	24
37	46355	88607	52316	191147	112858	215725	23
38	46381	88593	52353	191012	112875	215605	22
39	46407	88580	5239	190876	112892	215485	21
40	46433	88566	52427	190741	112910	215366	20
41	46458	88553	52464	190607	112927	215246	19
42	46484	88539	52501	190472	112944	215127	18
43	46510	88526	52538	190337	112961	215008	17
44	46536	88512	52575	190203	112979	214889	16
45	46561	88499	52613	190069	112996	214770	15
46	46587	88485	52650	189935	113013	214651	14
47	46613	88472	52687	189810	113031	214533	13
48	46639	88458	52724	189667	113048	214414	12
49	46664	88445	52761	189533	113065	214296	11
50	46690	88431	52798	189400	113083	214178	10
51	46716	88417	52836	189266	113000	214060	9
52	46742	88404	52873	189133	113117	213942	8
53	46767	88390	52910	189000	113135	213825	7
54	46793	88377	52947	188867	113152	213707	6
55	46819	88363	52985	188734	113170	213590	5
56	46844	88349	53022	188602	113187	213473	4
57	46870	88336	53059	188469	113205	213356	3
58	46896	88322	53096	188337	113222	213239	2
59	46921	88308	53134	188205	113239	213122	1
60	46947	88295	53171	188073	113257	213005	0

H

62

A TABLE OF

28

28	Sines		Tangents		Secants		
1	46973	88281	53208	187945	113273	212889	59
2	45999	88267	53246	187809	113292	212773	58
3	47024	88254	53283	187677	113310	212657	57
4	47050	88240	53320	187546	113327	212540	56
5	47076	88226	53358	187415	113345	212425	55
6	47 01	88213	53395	187283	113362	212309	54
7	47127	88199	53432	187152	113380	212193	53
8	47152	88185	53470	187021	113398	2120 8	52
9	47178	88172	53507	186891	113415	211963	51
10	47204	88158	53545	186760	113433	211847	50
11	47229	88144	53582	186630	113451	211732	49
12	47255	88130	53620	186499	113468	211617	48
13	47281	88117	53657	186369	113486	211503	47
14	47306	88103	53694	186239	113504	211388	46
15	47332	88089	53732	186109	113521	211274	45
16	47358	88075	53769	185979	113539	211159	44
17	47 83	88062	53807	185850	113557	211045	43
18	47409	88048	53844	185720	113575	210931	42
19	47434	88034	53882	185591	113593	210817	41
20	47460	88020	53920	185462	113610	210704	40
21	47486	88006	53957	185332	113628	210590	39
22	47511	87993	53995	185204	113646	210477	38
23	47537	87979	54032	185075	113664	210363	37
24	47562	87965	54070	184946	113682	210250	36
25	47588	87951	54107	184818	113700	210137	35
26	47614	87937	54145	184689	113718	210024	34
27	47639	87923	54183	184561	113735	209911	33
28	47665	87909	54220	184433	113753	209799	32
29	47690	87896	54258	184305	113771	209686	31
30	47716	87882	54296	184177	113789	209574	30

A TABLE OF

28

Sines

Tangents

Secants

31	47741	87868	54333	184049	113807	209462	29
32	47767	87854	54371	183922	113825	209350	28
33	47793	87840	54409	183794	113843	209238	27
34	47818	87826	54446	183667	113861	209126	26
35	47844	87812	54484	183540	113879	209015	25
36	47869	87798	54522	183413	113897	208903	24
37	47895	87784	54560	183286	113916	208791	23
38	47920	87770	54597	183159	113934	208680	22
39	47946	87756	54635	183033	113952	208569	21
40	47971	87743	54673	182906	113970	208458	20
41	47997	87729	54711	182780	113988	208347	19
42	48022	87715	54748	182654	114006	208236	18
43	48048	87701	54786	182528	114024	208126	17
44	48073	87687	54824	182402	114042	208015	16
45	48099	87673	54862	182276	114061	207905	15
46	48124	87659	54900	182150	114079	207795	14
47	48150	87645	54938	182025	114097	207685	13
48	48175	87631	54975	181899	114115	207575	12
49	48201	87617	55013	181774	114134	207467	11
50	48226	87603	55051	181649	114152	207356	10
51	48252	87589	55089	181524	114170	207246	9
52	48277	87575	55127	181399	114188	207137	8
53	48303	87561	55165	181274	114207	207021	7
54	48328	87546	55203	181150	114225	206918	6
55	48354	87532	55241	181025	114243	206809	5
56	48379	87518	55279	180901	114262	206701	4
57	48405	87504	55317	180777	114280	206592	3
58	48431	87490	55355	180653	114299	206483	2
59	48456	87476	55393	180529	114317	206374	1
60	48481	87462	55431	180405	114335	206267	0

H 2

01

A TABLE OF

29

Sines

Tangents

Secants

1	48506	87448	55469	180281	114354	206158	59
2	48532	87434	55507	180158	114372	206050	58
3	48557	87420	55545	180034	114391	205942	57
4	48583	87406	55583	179911	114409	205835	56
5	48608	87391	55621	179788	114428	205727	55
6	48634	87377	55659	179665	114446	205619	54
7	48659	87363	55697	179544	114465	205512	53
8	48684	87349	55735	179419	114483	205405	52
9	48710	87335	55774	179296	114502	205298	51
10	48735	87321	55812	179174	114521	205191	50
11	48761	87306	55850	179051	114539	205084	49
12	48786	87292	55888	178929	114558	204977	48
13	48811	87278	55926	178807	114576	204870	47
14	48837	87264	55964	178685	114595	204764	46
15	48862	87250	56003	178563	114614	204658	45
16	48887	87235	56041	178441	114632	204551	44
17	48913	87221	56079	178319	114651	204445	43
18	48938	87207	56117	178198	114670	204339	42
19	48964	87193	56156	178077	114688	204233	41
20	48989	87178	56194	177955	114707	204128	40
21	49014	87164	56232	177834	114726	204022	39
22	49040	87150	56270	177713	114745	203916	38
23	49065	87136	56309	177592	114764	203811	37
24	49090	87121	56347	177471	114782	203706	36
25	49116	87107	56385	177351	114801	203601	35
26	49141	87093	56424	177230	114820	203496	34
27	49166	87079	56462	177110	114839	203391	33
28	49192	87064	56500	176990	114858	203286	32
29	49217	87050	56538	176869	114877	203182	31
30	49242	87036	56576	176749	114896	203077	30

TABLE OF

	Sines		Tangents		Secants		
29							
31	49268	87021	56616	176630	114914	202973	29
32	49293	87007	56654	176510	114933	202869	28
33	49318	86993	56693	176390	114952	202765	27
34	49344	86978	56731	176271	114972	202661	26
35	49369	86964	56769	176151	114990	202557	25
36	49394	86949	56808	176032	115009	202453	24
37	49419	86935	56846	175913	115028	202349	23
38	49445	86921	56885	175794	115047	202246	22
39	49470	86906	56923	175675	115067	202143	21
40	49495	86892	56962	175556	115086	202039	20
41	49521	86878	57000	175437	115104	201936	19
42	49546	86863	57039	175319	115124	201833	18
43	49571	86849	57078	175200	115142	201730	17
44	49596	86834	57116	175082	115162	201628	16
45	49622	86820	57155	174964	115181	201525	15
46	49647	86805	57193	174846	115200	201422	14
47	49672	86791	57232	174728	115219	201320	13
48	49697	86777	57271	174610	115238	201218	12
49	49723	86763	57309	174492	115258	201116	11
50	49748	86748	57348	174375	115277	201014	10
51	49773	86733	57386	174257	115296	200912	9
52	49798	86719	57425	174140	115315	200810	8
53	49824	86704	57464	174022	115335	200708	7
54	49849	86690	57503	173905	115354	200607	6
55	49874	86675	57541	173788	115372	200505	5
56	49899	86661	57580	173671	115393	200404	4
57	49924	86646	57619	173555	115412	200303	3
58	49950	86632	57657	173438	115431	200202	2
59	49975	86617	57696	173321	115451	200101	1
60	50000	86603	57735	173205	115470	200000	0

A TABLE OF

30	Sines		Tangents		Secants		
1	50025	86588	57774	173089	115489	199899	59
2	50050	89573	57813	172973	115509	199799	58
3	50076	86559	57851	172857	115528	199698	57
4	50101	86544	57890	172741	115548	199598	56
5	50126	86530	57929	172625	115564	199498	55
6	50151	86515	57968	172509	115587	199398	54
7	50176	86501	58007	172393	115606	199298	53
8	50201	86486	58046	172278	115626	199198	52
9	50227	86471	58085	172163	115645	199098	51
10	50252	86457	58124	172047	115665	198998	50
11	50277	86442	58162	171932	115684	198899	49
12	50302	86427	58201	171817	115704	198799	48
13	50327	86413	58240	171702	115724	198700	47
14	50352	86398	58279	171588	115743	198601	46
15	50377	86384	58318	171473	115763	198502	45
16	50403	86369	58357	171358	115782	198403	44
17	50428	86354	58397	171244	115802	198304	43
18	50453	86340	58435	171130	115822	198205	42
19	50478	86325	58474	171015	115841	198107	41
20	50503	86310	58513	170901	115861	198008	40
21	50528	86295	58552	170787	115881	197909	39
22	50553	86281	58591	170673	115901	197811	38
23	50578	86266	58631	170560	115920	197713	37
24	50603	86251	58670	170446	115940	197615	36
25	50628	86237	58709	170332	115960	197517	35
26	50654	86222	58748	170219	115980	197420	34
27	50679	86207	58787	170106	116000	197322	33
28	50704	86192	58826	169992	116019	197224	32
29	50729	86178	58865	169879	116039	197127	31
30	50754	86163	58905	169766	116059	197029	30

A TABLE OF

30

	Sines		Tangents		Secants		
31	50779	86148	58944	169653	116079	196932	29
32	50804	86133	58983	169541	116099	196835	28
33	50829	86119	59022	169428	116119	196738	27
34	50854	86104	59061	169315	116139	196641	26
35	50879	86089	59101	169203	116159	196544	25
36	50904	86074	59140	169091	116179	196448	24
37	50929	86059	59179	168979	116199	196351	23
38	50954	86045	59218	168866	116219	196255	22
39	50979	86030	59258	168754	116239	196158	21
40	51004	86016	59297	168643	116259	196062	20
41	51029	86000	59337	168531	116279	195966	19
42	51053	85985	59376	168419	116299	195870	18
43	51079	85970	59415	168308	116319	195774	17
44	51104	85956	59454	168196	116339	195678	16
45	51129	85941	59494	168085	116359	195583	15
46	51154	85926	59533	167974	116380	195487	14
47	51179	85911	59573	167863	116400	195391	13
48	51204	85896	59612	167752	116419	195296	12
49	51229	85881	59651	167641	116440	195201	11
50	51254	85866	59691	167530	116460	195106	10
51	51279	85851	59730	167419	116480	195011	9
52	51304	85836	59770	167309	116501	194916	8
53	51329	85821	59809	167198	116521	194821	7
54	51354	85806	59849	167088	116541	194726	6
55	51379	85792	59888	166978	116562	194632	5
56	51404	85777	59928	166867	116582	194537	4
57	51429	85762	59967	166757	116602	194443	3
58	51454	85747	60007	166647	116623	194349	2
59	51479	85732	60046	166538	116643	194254	1
60	51504	84717	60086	166428	116663	194160	0

A TABLE OF

31

	Sines		Tangents		Secants		
1	51529	85703	60126	166318	116684	194066	59
2	51554	85687	60165	166209	116704	193973	58
3	51579	85672	60205	166099	116724	193879	57
4	51604	85657	60245	165990	116745	193783	56
5	51628	85642	60284	165881	116765	193692	55
6	51653	85627	60324	165772	116786	193598	54
7	51678	85612	60364	165663	116806	193505	53
8	51703	85597	60403	165554	116827	193412	52
9	51728	85582	60443	165445	116848	193319	51
10	51753	85567	60483	165337	116868	193226	50
11	51778	85551	60522	165228	116889	193133	49
12	51803	85536	60562	165120	116909	193040	48
13	51828	85521	60602	165011	116930	192947	47
14	51852	85506	60642	164903	116950	192855	46
15	51877	85491	60681	164795	116971	192762	45
16	51902	85476	60721	164687	116992	192670	44
17	51927	85461	60761	164579	117012	192578	43
18	51952	85446	60801	164471	117033	192486	42
19	51977	85431	60841	164363	117054	192394	41
20	52002	85416	60881	164256	117075	192302	40
21	52026	85401	60921	164148	117095	192210	39
22	52051	85385	60960	164041	117116	192118	38
23	52076	85370	61000	163934	117137	192027	37
24	52100	85355	61040	163826	117158	191935	36
25	52126	85340	61086	163719	117179	191844	35
26	52151	85325	61120	163612	117199	191752	34
27	52175	85310	61160	163505	117220	191661	33
28	52200	85294	61200	163398	117241	191570	32
29	52225	85279	61240	163292	117262	191479	31
30	52250	85264	61280	163185	117283	191388	30

A TABLE OF

31

Sines

Tangents

Secants

31	52275	85249	61320	163079	117304	191297	29
32	52299	85234	61360	162972	117325	191207	28
33	52324	85218	61400	162866	117346	191116	27
34	52349	85203	61440	162760	117367	191025	26
35	52374	85188	61480	162654	117388	190935	25
36	52399	85173	61520	162548	117409	190845	24
37	52423	85157	61561	162442	117430	190755	23
38	52448	85142	61601	162336	117451	190665	22
39	52473	85127	61641	162230	117472	190575	21
40	52498	85112	61681	162125	117493	190485	20
41	52522	85096	61721	162019	117514	190395	19
42	52547	85081	61761	161912	117535	190305	18
43	52572	85066	61801	161809	117556	190215	17
44	52597	85051	61842	161703	117577	190126	16
45	52621	85035	61882	161598	117598	190037	15
46	52646	85020	61922	161493	117620	189948	14
47	52671	85005	61963	161388	117641	189858	13
48	52696	84989	62003	161284	117662	189769	12
49	52720	84974	62043	161179	117683	189680	11
50	52745	84959	62083	161074	117704	189591	10
51	52770	84943	62124	160970	117726	189503	9
52	52794	84928	62164	160865	117747	189414	8
53	52819	84913	62204	160761	117768	189325	7
54	52844	84897	62245	160657	117790	189237	6
55	52869	84882	62285	160553	117811	189148	5
56	52893	84866	62325	160449	117832	189060	4
57	52918	84851	62366	160345	117854	188972	3
58	52943	84836	62406	160241	117875	188884	2
59	52967	84820	62446	160137	117896	188796	1
60	52992	84805	62487	160033	117918	188708	0

f

58

A TABLE OF

32

Sines

Tangents

Secants

1	53017	84789	62527	159930	117939	188620	59
2	53041	84773	62568	159827	117961	188533	58
3	53066	84759	62608	159723	117982	188445	57
4	53091	84743	62649	159620	118004	188357	56
5	53115	84728	62689	159517	118025	188270	55
6	53140	84712	62730	159414	118047	188183	54
7	53164	84697	62770	159311	118068	188095	53
8	53189	84681	62811	159208	118090	188008	52
9	53214	84666	62852	159105	118111	187921	51
10	53238	84650	62892	159002	118133	187834	50
11	53263	84635	62933	158900	118155	187748	49
12	53288	84619	62973	158797	118176	187661	48
13	53312	84604	63014	158695	118198	187574	47
14	53337	84588	63055	158593	118220	187488	46
15	53361	84573	63095	158490	118241	187401	45
16	53386	84557	63136	158388	118263	187315	44
17	53411	84542	63177	158286	118285	187229	43
18	53435	84526	63217	158184	118307	187142	42
19	53460	84511	63258	158083	118328	187056	41
20	53484	84495	63299	157981	118350	186970	40
21	53509	84480	63340	157879	118372	186885	39
22	53534	84464	63380	157778	118394	186799	38
23	53558	84448	63421	157676	118416	186713	37
24	53583	84433	63462	157575	118437	186627	36
25	53607	84417	63503	157474	118459	186542	35
26	53632	84402	63543	157372	118481	186457	34
27	53656	84386	63584	157271	118503	186371	33
28	53681	84370	63625	157170	118525	186286	32
29	53705	84355	63666	157069	118547	186201	31
30	53730	84339	63707	156969	118569	186116	30

A TABLE OF

32

31	53754	84324	63748	156868	118591	186031	29
32	53779	84308	63789	156757	118613	185946	28
33	53804	84292	63830	156667	118635	185861	27
34	53828	84277	63871	156566	118657	185777	26
35	53853	84261	63912	156466	118679	185692	25
36	53877	84245	63953	156366	118701	185608	24
37	53902	84230	63994	156265	118723	185523	23
38	53926	84214	64035	156165	118745	185439	22
39	53951	84198	64076	156065	118767	185355	21
40	53975	84182	64117	155966	118790	185271	20
41	53999	84167	64158	155866	118812	185187	19
42	54024	84151	64199	155766	118834	185103	18
43	54049	84135	64240	155666	118856	185019	17
44	54073	84120	64281	155567	118878	184935	16
45	54097	84104	64322	155467	118901	184852	15
46	54122	84088	64363	155368	118923	184768	14
47	54146	84072	64404	155269	118945	184685	13
48	54171	84057	64446	155170	118967	184601	12
49	54195	84041	64487	155071	118990	184518	11
50	54220	84025	64528	154972	119012	184435	10
51	54244	84009	64569	154873	119034	184352	9
52	54269	83994	64610	154774	119057	184269	8
53	54293	83978	64652	154675	119079	184186	7
54	54317	83962	64693	154576	119102	184103	6
55	54342	83946	64734	154478	119124	184020	5
56	54366	83930	64775	154379	119146	183938	4
57	54391	83915	64817	154281	119169	183855	3
58	54415	83899	64858	154183	119191	183773	2
59	54439	83883	64899	154085	119214	183690	1
60	54464	83867	64941	153987	119236	183608	0

A TABLE OF

33

Sines

Tangents

Secants

1	54488	83851	64982	153883	119259	183526	59
2	54513	83835	65023	153798	119281	183444	58
3	54537	83819	65065	153693	119304	183362	57
4	54561	83804	65106	153595	119327	183280	56
5	54586	83788	65148	153497	119349	183198	55
6	54610	83772	15189	153400	119372	183116	54
7	54635	83756	65231	153302	119394	183034	53
8	54658	83740	65272	153205	119417	182953	52
9	54683	83724	65314	153107	119440	182871	51
10	54708	83708	65355	153010	119463	182790	50
11	54732	83692	65397	152913	119485	182709	49
12	54756	83676	65438	152816	119508	182627	48
13	54781	83661	65480	152719	119531	182546	47
14	54805	83645	65521	152622	119553	182465	46
15	54829	83629	65563	152525	119576	182384	45
16	54854	83613	65602	152429	119599	182303	44
17	54878	83597	65646	152332	119622	182222	43
18	54902	83581	65688	152235	119645	182142	42
19	54927	83565	65729	152139	119668	182061	41
20	54951	83549	65771	152043	119691	181981	40
21	54975	83533	65813	151946	119713	181900	39
22	54999	83517	65854	151850	119736	181820	38
23	55024	83501	65896	151754	119759	181740	37
24	55048	83485	65938	151658	119782	181659	36
25	55072	83469	65980	151562	119805	181579	35
26	55097	83453	66021	151466	119828	181499	34
27	55121	83437	66063	151370	119851	181419	33
28	55145	83421	66105	151275	119874	181340	32
29	55169	83405	66147	151179	119897	181260	31
30	55194	83389	66189	151084	119920	181180	30

TABLE OF

	Sines		Tangents		Secants		
33							
31	55218	83373	66230	150988	119944	181101	29
32	55242	83356	66272	150893	119967	181021	28
33	55266	83340	66314	150797	119990	180941	27
34	55291	83324	66356	150702	120013	180862	26
35	55315	83308	66398	150607	120036	180783	25
36	55339	83292	66440	150512	120059	180704	24
37	55363	83276	66482	150417	120083	180624	23
38	55388	83260	66524	150322	120106	180546	22
39	55412	83244	66566	150228	120129	180467	21
40	55436	83228	66608	150133	120152	180388	20
41	55460	83212	66650	150038	120176	180309	19
42	55484	83195	66692	149944	120199	180231	18
43	55509	83179	66734	149849	120222	180152	17
44	55533	83163	66776	149755	120246	180074	16
45	55557	83147	66818	149661	120269	179995	15
46	55581	83131	66860	149566	120292	179917	14
47	55605	83115	66902	149472	120316	179839	13
48	55630	83098	66944	149378	120339	179761	12
49	55654	83082	66986	149284	120363	179682	11
50	55678	83066	67028	149190	120386	179604	10
51	55702	83050	67071	144097	120410	179527	9
52	55726	83034	67113	149093	120433	179449	8
53	55750	83017	67155	148909	120457	179371	7
54	55775	83001	67197	148816	120480	179293	6
55	55799	82985	67239	148722	120504	179216	5
56	55823	82969	67282	148629	120527	179138	4
57	55847	82953	67324	148536	120551	179061	3
58	55871	82936	67366	148442	120575	178984	2
59	55895	82920	67409	148349	120598	178906	1
60	55919	82904	67451	148256	120622	178829	0

A TABLE OF

34

	Sines		Tangents		Secants		
1	55943	82888	67493	148163	120645	178752	59
2	55968	82871	67536	148070	120669	178675	58
3	55992	82855	67578	147977	120693	178598	57
4	56016	82839	67620	147885	120717	178521	56
5	56040	82825	67663	147792	120740	178445	55
6	56064	82806	67705	147699	120764	178368	54
7	56088	82790	67748	147607	120788	178291	53
8	56112	82773	67790	147514	120812	178215	52
9	56136	82757	67832	147422	120836	178138	51
10	56160	82741	67874	147330	120859	178062	50
11	56184	82724	67917	147238	120883	177986	49
12	56208	82708	67960	147146	120907	177910	48
13	56232	82692	68002	147053	120931	177833	47
14	56256	82675	68045	146962	120955	177757	46
15	56280	82659	68088	146870	120979	177681	45
16	56305	82643	68130	146778	121003	177606	44
17	56329	82626	68173	146686	121027	177530	43
18	56353	82610	68215	146594	121051	177454	42
19	56377	82593	68258	146503	121075	177379	41
20	56401	82577	68301	146411	121099	177303	40
21	56425	82561	68343	146320	121123	177227	39
22	56449	82544	68386	146229	121147	177152	38
23	56473	82528	68429	146137	121171	177077	37
24	56497	82511	68471	146046	121195	177002	36
25	56521	82495	68514	145955	121220	176926	35
26	56545	82478	68557	145864	121244	176851	34
27	56569	82462	68600	145773	121268	176776	33
28	56593	82446	68642	145682	121292	176701	32
29	56617	82429	68685	145592	121316	176627	31
30	56641	82413	68728	145501	121341	176552	30

A TABLE OF

34

	Sines		Tangents		Secants		
31	56665	82396	68771	145410	121365	176477	29
32	56689	82380	68814	145320	121389	176402	28
33	56713	82363	68857	145229	121414	176328	27
34	56736	82347	68900	145132	121438	176253	26
35	56760	82330	68942	145048	121462	176179	25
36	56784	82314	68985	144958	121487	196105	24
37	56808	82297	69028	144868	121511	176031	23
38	56832	82281	69071	144778	121535	175956	22
39	56856	82264	69114	144688	121560	175882	21
40	56880	82248	69157	144598	121584	175808	20
41	56904	82132	69200	144508	121609	175734	19
42	56928	82115	69243	144418	121633	175661	18
43	56952	82198	69286	144329	121658	175587	17
44	56976	82181	69329	144239	121682	175513	16
45	57000	82165	69372	144149	121707	175440	15
46	57024	82148	69416	144060	121731	175366	14
47	57047	82132	69459	143970	121756	175293	13
48	57071	82115	69502	143881	121781	175219	12
49	57095	82098	69545	143792	121805	175146	11
50	57119	82082	69588	143703	121830	175073	10
51	57143	82065	69631	143614	121854	175000	9
52	57167	82048	69675	143524	121879	174926	8
53	57191	82032	69718	143436	121903	174854	7
54	57215	82015	69761	143347	121929	174781	6
55	57238	81999	69804	143258	121953	174708	5
56	57262	81982	69847	143169	121978	174635	4
57	57286	81965	69891	143080	122003	174563	3
58	47310	81949	69934	142992	122028	174490	2
59	57334	81932	69977	142903	122053	174417	1
60	57358	81915	70021	142815	122077	174345	0

A TABLE OF

35

Sines

Tangents

Secants

1	57381	81899	70064	142736	122102	174272	59
2	57405	81882	70107	142638	122127	174200	58
3	57429	81865	70151	142550	122152	174128	57
4	57453	81848	70194	142462	122177	174056	56
5	57477	81832	70238	142374	122202	173983	55
6	57501	81815	70281	142286	122227	173911	54
7	57524	81798	70325	142198	122252	173840	53
8	57548	81782	70368	142110	122277	173768	52
9	57572	81765	70412	142022	122302	173696	51
10	57596	81748	70455	141934	122327	173624	50
11	57619	81731	70499	141847	122352	173552	49
12	57643	81714	70542	141759	122377	173481	48
13	57667	81698	70586	141672	122402	173409	47
14	57691	81681	70629	141584	122428	173338	46
15	57715	81664	70673	141497	122453	173267	45
16	57738	81647	70717	141409	122478	173195	44
17	57762	81631	70760	141322	122503	173124	43
18	57786	81614	70804	141235	122528	173053	42
19	57810	81597	70848	141148	122554	172982	41
20	57833	81580	70891	141061	122579	172911	40
21	57857	81563	70935	140974	122604	172840	39
22	57881	81546	70979	140887	122629	172769	38
23	57904	81530	71023	140800	122655	172698	37
24	57928	81513	71066	140714	122680	172628	36
25	57952	81496	71110	140627	122706	172557	35
26	57976	81479	71154	140540	122731	172487	34
27	57999	81462	71198	140454	122756	172416	33
28	58023	81445	71242	140367	122782	172346	32
29	58047	81428	71285	140281	122807	172275	31
30	58070	81412	71329	140195	122833	172205	30

A TABLE OF

35

Sines

Tangents

Secants

31	58094	81395	71373	140109	122858	172135	29
32	58118	81378	71417	140022	122884	172065	28
33	58141	81361	71461	139936	122909	171995	27
34	58165	81344	71505	139850	122935	171925	26
35	58189	81327	71549	139764	122961	171855	25
36	58212	81310	71593	139679	122986	171785	24
37	58236	81293	71637	139593	123012	171715	23
38	58260	81276	71681	139507	123037	171646	22
39	58283	81259	71725	139421	123063	171576	21
40	58307	81242	71769	139336	123089	171506	20
41	58330	81225	71813	139250	123114	171437	19
42	58354	81208	71857	139165	123140	171367	18
43	58378	81191	71901	139079	123166	171298	17
44	58401	81174	71946	138994	123192	171229	16
45	58425	81157	71990	138909	123217	171160	15
46	58449	81140	72034	138824	123243	171091	14
47	58472	81123	72078	138738	123269	171021	13
48	58499	81106	72122	138653	123295	170952	12
49	58519	81089	72166	138568	123321	170884	11
50	58543	81072	72211	138484	123347	170815	10
51	58567	81055	72255	138399	123373	170746	9
52	58593	81008	72299	138314	123399	170675	8
53	58616	81021	72344	138229	123424	170609	7
54	58637	81004	72388	138145	123450	170540	6
55	58661	80987	72432	138060	123476	170472	5
56	58684	80970	72477	137976	123502	170403	4
57	58708	80953	72521	137891	123529	170335	3
58	58731	80936	72565	137807	123555	170267	2
59	58755	80919	72610	137722	123581	170198	1
60	58779	80902	72654	137638	123607	170130	0

K

54

A TABLE OF

36

Sines

Tangents

Secants

1	58302	80885	72699	137554	123632	170062	59
2	58826	80867	72743	137470	123659	169994	58
3	58849	80850	72788	137386	123685	169926	57
4	58373	80833	72832	137302	123711	169858	56
5	58896	80816	72877	137218	123738	169790	55
6	58920	80799	72921	137134	123764	169723	54
7	58943	80782	72966	137050	123790	169655	53
8	58967	80765	73010	136967	123816	169587	52
9	58990	80748	73055	136883	123843	169520	51
10	59014	80730	73100	136800	123869	169453	50
11	59037	80713	73144	136716	123895	169385	49
12	59061	80696	73189	136633	123922	169318	48
13	59084	80679	73234	136549	123948	169250	47
14	59107	80662	73278	136466	123975	169183	46
15	59131	80644	73323	136383	124001	169116	45
16	59154	80627	73368	136300	124028	169049	44
17	59178	80610	73413	136217	124054	168982	43
18	59201	80593	73457	136133	124081	168915	42
19	59225	80576	73502	136051	124107	168848	41
20	59248	80558	73547	135968	124134	168782	40
21	59272	80541	73592	135885	124160	168715	39
22	59295	80524	73637	135802	124187	168648	38
23	59318	80507	73681	135719	124213	168582	37
24	59342	80489	73726	135637	124240	168515	36
25	59365	80472	73771	135554	124267	168449	35
26	59389	80455	73816	135472	124293	168382	34
27	59412	80438	73861	135389	124320	168316	33
28	59436	80420	73905	135307	124347	168250	32
29	59460	80403	73951	135224	124373	168183	31
30	59484	80386	73996	135142	124400	168117	30

A TABLE OF

26

	Sines		Tangents		Secants		
31	59506	80368	74041	135060	12427	168051	29
32	59529	80351	74086	134978	124454	167985	28
33	59552	80334	74131	134896	124481	167919	27
34	59576	80316	74176	134814	124508	167853	26
35	59599	80299	74221	134732	124534	167788	25
36	59623	80282	74267	134650	124561	167722	24
37	59646	80264	74312	134568	124588	167656	23
38	59669	80247	74357	134487	124615	167591	22
39	59693	80230	74402	134405	124643	167525	21
40	59716	80212	74447	134323	124669	167460	20
41	59739	80195	74492	134242	124696	167394	19
42	59763	80178	74538	134160	124723	167329	18
43	59786	80160	74583	134079	124750	167264	17
44	59809	80143	74628	133998	124777	167199	16
45	59832	80125	74674	133916	124804	167133	15
46	59856	80108	74719	133835	124832	167068	14
47	59879	80091	74764	133754	124859	167003	13
48	59902	80073	74810	133673	124886	166938	12
49	59926	80056	74855	133592	124913	166873	11
50	59949	80038	74900	133511	124940	166809	10
51	59972	80021	74946	133430	124967	166744	9
52	59995	80003	74991	133349	124995	166679	8
53	60019	79986	75037	133268	125022	166615	7
54	60042	79968	75082	133187	125049	166550	6
55	60065	79951	75128	133107	125077	166486	5
56	60089	79934	75173	133026	125104	166421	4
57	60112	79916	75219	132946	125131	166357	3
58	60135	79899	75264	132865	125159	166292	2
59	60159	79881	75310	132785	125186	166228	1
60	60181	79864	75355	132704	125214	166164	0

K 2

53

A TABLE OF

37

	Sines		Tangents		Secants		
1	60205	79846	75401	132624	125241	166100	59
2	60228	79829	75447	132544	125269	166036	58
3	60251	79811	75492	132464	125296	165972	57
4	60274	79793	75538	132384	125324	165908	56
5	60298	79776	75584	132304	125351	165844	55
6	60321	79758	75629	132224	125379	165780	54
7	60344	79741	75675	132144	125406	165716	53
8	60367	79723	75721	132064	125434	165653	52
9	60390	79702	75767	131984	125462	165589	51
10	60414	79688	75812	131904	125489	165526	50
11	60437	79671	75858	131825	125517	165462	49
12	60460	79653	75904	131745	125545	165399	48
13	60483	79635	75950	131666	125572	165335	47
14	60506	79618	75996	131586	125600	165272	46
15	60529	79600	76042	131507	125628	165209	45
16	60553	79583	76088	131427	125656	165146	44
17	60576	79567	76138	131348	125683	165083	43
18	60599	79547	76180	131269	125711	165020	42
19	60622	79530	76226	131190	125739	164957	41
20	60645	79512	76272	131110	125767	164894	40
21	60668	79494	76318	131031	125796	164831	39
22	60691	79477	76364	130952	125821	164768	38
23	60714	79459	76410	130873	125851	164705	37
24	60738	79441	76456	130795	125879	164643	36
25	60761	79424	76502	130716	125907	164580	35
26	60784	79406	76548	130637	125935	164518	34
27	60807	79388	76594	130558	125963	164455	33
28	60830	79371	76640	130480	125991	164393	32
29	60853	79353	76686	130401	126019	164330	31
30	60876	79335	76732	130323	126047	164268	30

TABLE OF

	Sines		Tangents		Secants		
37	60899	79318	76779	130244	126075	164206	29
32	60922	79300	76825	130166	126104	164144	28
33	60945	79282	76871	130087	126132	164082	27
34	60968	79264	76918	130009	126160	164019	26
35	60991	79247	76964	129931	126188	163957	25
36	60015	79229	77010	129853	126216	163895	24
37	61038	79211	77057	129775	126245	163835	23
38	61061	79193	77103	129696	126273	163772	22
39	61084	79176	77149	129618	126301	163710	21
40	61107	79158	77196	129541	126330	163648	20
41	61130	79140	77242	129464	126358	163587	19
42	61153	79122	77289	129385	126387	163525	18
43	61176	79105	77335	129307	126416	163464	17
44	61199	79087	77382	129229	126443	163402	16
45	61202	79269	77428	129152	126472	163341	15
46	61245	79051	77475	129073	126500	163279	14
47	61268	79033	77521	128997	126529	163218	13
48	61291	79015	77568	128919	126557	163157	12
49	61314	78998	77615	128842	126586	163096	11
50	61337	78980	77661	128765	126615	163035	10
51	61360	78962	77708	128687	126643	162974	9
52	61383	78944	77754	128610	126672	162913	8
53	61406	78927	77801	128533	126701	162852	7
54	61429	78908	77848	128455	126729	162791	6
55	61451	78891	77895	128379	126758	162730	5
56	61474	78873	77941	128402	126787	162669	4
57	61497	78855	77988	128225	126815	162609	3
58	61520	78837	78035	128148	126844	162548	2
59	61543	78819	78082	128071	126873	162487	1
60	61566	78801	78129	127994	126902	162427	0

A TABLE OF

33

	Sines		Tangents		Secants		
1	61589	78783	78175	127917	126931	162366	59
2	61512	78765	78222	127841	126960	162306	58
3	61635	78747	78269	127704	126988	162246	57
4	61658	78729	78316	127688	127017	162185	56
5	61681	78711	78363	127611	127046	162125	55
6	61703	78693	78410	127535	127075	162065	54
7	61726	78676	78457	127458	127104	162005	53
8	61749	78658	78504	127382	127133	161945	52
9	61772	78640	78551	127306	127162	161885	51
10	61795	78622	78598	127230	127191	161825	50
11	61818	78604	78645	127153	127221	161765	49
12	61841	78586	78692	127077	127250	161705	48
13	61864	78568	78739	127001	127279	161646	47
14	61887	78550	78786	126925	127308	161586	46
15	61909	78532	78834	126849	127337	161526	45
16	61932	78514	78881	126773	127366	161467	44
17	61955	78496	78928	126698	127396	161407	43
18	61978	78478	78975	126623	127425	161348	42
19	62001	78460	79012	126546	127454	161288	41
20	62024	78442	79070	126471	127483	161229	40
21	62046	78424	79117	126395	127513	161170	39
22	62069	78405	79164	126319	127542	161111	38
23	62092	78387	79212	126244	127572	161051	37
24	62115	78369	79259	126169	127601	160992	36
25	62138	78351	79306	126093	127630	160933	35
26	62160	78333	79354	126018	127660	160875	34
27	62183	78315	79401	125943	127689	160814	33
28	62206	78297	79449	125867	127719	160756	32
29	62229	78279	79496	125792	127748	160698	31
30	62251	78261	79544	125717	127778	160639	30

A TABLE OF

38

	Sines		Tangents		Secants		
31	62274	78243	79591	125642	127807	160580	29
32	62297	78225	79639	125567	127837	160521	28
33	62320	78206	79686	125492	127867	160463	27
34	62341	78188	79734	125417	127896	160404	26
35	62365	78170	79781	125343	127925	160346	25
36	62388	78152	79829	125268	127956	160287	24
37	62411	78134	79877	125193	127985	160229	23
38	62433	78116	79924	125118	128015	160171	22
39	62456	78098	79972	125044	128045	160112	21
40	62479	78079	80020	124969	128075	160054	20
41	62502	78061	80067	124895	128105	159996	19
42	62524	78043	80115	124820	128134	159938	18
43	62547	78025	80163	124745	128164	159880	17
44	62570	78007	80211	124672	128194	159822	16
45	62592	77988	80258	124597	128224	159764	15
46	62615	77970	80306	124523	128254	159706	14
47	62638	77952	80354	124449	128284	159648	13
48	62660	77934	80402	124375	128314	159590	12
49	62683	77916	80450	124301	128344	159533	11
50	62703	77897	80498	124227	128374	159475	10
51	62728	77879	80545	124153	128404	159417	9
52	62751	77861	80594	124080	128434	159361	8
53	62774	77843	80642	124005	128464	159302	7
54	62796	77824	80690	123931	128495	159245	6
55	62819	77805	80738	123858	128525	159188	5
56	62842	77788	80786	123784	128555	159130	4
57	62854	77769	80834	123710	128585	159073	3
58	62887	77751	80882	123637	128615	159016	2
59	62909	77733	80930	123562	128646	158959	1
60	62932	77715	80977	123490	128676	158902	0

A TABLE OF

39

	Sines		Tangents		Secants		
1	62955	77696	81027	123416	128706	158845	59
2	62977	77678	81075	123343	128737	158788	58
3	63000	77660	81123	123270	128767	158731	57
4	63022	77641	81171	123196	128797	158674	56
5	63045	77623	81220	123123	128828	158617	55
6	63068	77605	81268	123050	128858	158560	54
7	63090	77586	81316	122977	128889	158503	53
8	63113	77568	81365	122904	128919	158447	52
9	63135	77550	81413	122831	128950	158390	51
10	63158	77531	81461	122758	128980	158333	50
11	63180	77513	81510	122685	129011	158277	49
12	63203	77494	81558	122612	129042	158221	48
13	63225	77476	81606	122539	129072	158164	47
14	63248	77458	81655	122467	129103	158108	46
15	63271	77439	81703	122394	129134	158051	45
16	63293	77421	81752	122321	129164	157995	44
17	63316	77402	81800	122249	129195	157939	43
18	63338	77384	81849	122176	129226	157883	42
19	63361	77366	81898	122104	129256	157827	41
20	63383	77347	81946	122031	129287	157771	40
21	63406	77329	81995	121959	129318	157715	39
22	63428	77310	82044	121886	129349	157659	38
23	63451	77292	82093	121814	129380	157603	37
24	63473	77273	82141	121742	129411	157547	36
25	63496	77255	82190	121670	129442	157491	35
26	63518	77236	82238	121598	129473	157436	34
27	63540	77218	82287	121526	129504	157380	33
28	63563	77199	82336	121454	129535	157324	32
29	63585	77181	82385	121382	129566	157269	31
30	63608	77162	82434	121310	129597	157213	30

50

A TABLE OF

39

Sines

Tangents

Secants

31	63630	77144	82482	121238	129628	157158	29
32	63653	77125	82531	121156	129639	157103	28
33	63675	77107	82580	121094	129690	157047	27
34	63698	77088	82629	121023	129721	156992	26
35	637 0	77020	82678	120951	129752	156937	25
36	63742	77051	82727	120879	129784	156881	24
37	63765	77033	82776	120808	129815	156826	23
38	63787	77014	82825	120736	129846	156771	22
39	63810	76996	82874	120665	129877	156716	21
40	63832	76977	82923	120593	129909	156661	20
41	63854	76959	82972	120522	129940	156606	19
42	63877	76940	83022	120451	129972	156551	18
43	63999	76921	83071	120379	130003	156497	17
44	63922	76903	83120	120308	130034	156442	16
45	63944	76884	83169	120237	130066	156387	15
46	63966	76865	83219	120166	130097	156332	14
47	63989	76847	83268	120095	130129	156278	13
48	64011	76828	83317	120024	130160	156223	12
49	64033	76810	83366	119953	130192	156169	11
50	64056	76791	83415	119882	130223	156114	10
51	64078	76772	83465	119811	130255	156060	9
52	64100	76754	83514	119740	130287	156005	8
53	64123	75736	83564	119669	130318	155951	7
54	64145	76717	83613	119599	130350	155897	6
55	64167	76698	83662	119528	130382	155843	5
56	64190	76679	83712	119457	130414	155789	4
57	64212	76661	83761	119387	130445	155734	3
58	64234	76642	83811	119316	130477	155680	2
59	64256	76623	83860	119246	130509	155626	1
60	64279	76604	83910	119175	130541	155572	0

L

50

A TABLE OF

40

	Sines		Tangents		Secants		
1	64301	76586	83960	119105	130573	155518	59
2	64323	76567	84009	119035	130605	155465	58
3	64346	76548	84059	118964	130636	155411	57
4	64368	76530	84108	118894	130668	155357	56
5	64390	76511	84158	118824	130700	155303	55
6	64412	76492	84208	118754	130732	155250	54
7	64435	76473	84258	118684	130764	155196	53
8	64457	76455	84307	118614	130797	155143	52
9	64479	76436	84357	118544	130829	155089	51
10	64501	76417	84407	118474	130861	155036	50
11	64524	76398	84457	118404	130893	154982	49
12	64546	76380	84507	118334	130925	154929	48
13	64568	76361	84556	118264	130957	154876	47
14	64590	76342	84606	118194	130989	154822	46
15	64612	76323	84656	118125	131022	154769	45
16	64635	76304	84706	118055	131054	154716	44
17	64657	76286	84756	117986	131086	154663	43
18	64679	76267	84806	117916	131119	154610	42
19	64701	76248	84856	117846	131151	154557	41
20	64723	76229	84906	117777	131183	154504	40
21	64745	76210	84956	117708	131216	154451	39
22	64768	76192	85006	117638	131248	154398	38
23	64790	76173	85057	117569	131281	154345	37
24	64812	76154	85107	117500	131313	154292	36
25	64834	76133	85157	117430	131346	154240	35
26	64856	76116	85207	117361	131378	154187	34
27	64878	76097	85257	117292	131411	154134	33
28	64901	76078	85307	117223	131443	154082	32
29	64923	76059	85358	117154	131475	154029	31
30	64945	76041	85408	117085	131509	153977	30

A TABLE OF

40

	Sines		Tangents		Secants		
31	64967	76022	85458	117016	131541	153924	29
32	64989	76003	85509	116947	131574	153872	28
33	65011	75984	85559	116878	131607	153820	27
34	65033	75965	85609	116809	131640	153768	26
35	65055	75946	85660	116741	131672	153715	25
36	65077	75927	85710	116672	131705	153663	24
37	65099	75908	85761	116603	131738	153611	23
38	65122	75889	85811	116535	131771	153559	22
39	65144	75870	85862	116466	131804	153507	21
40	65166	75851	85912	116398	131837	153455	20
41	65188	75832	85963	116329	131870	153403	19
42	65210	75813	86014	116261	131903	153351	18
43	65232	75794	86064	116192	131936	153299	17
44	65254	75775	86115	116124	131969	153247	16
45	65276	75756	86165	116056	132002	153196	15
46	65298	75738	86216	115987	132035	153144	14
47	65320	75719	86267	115919	132068	153092	13
48	65342	75700	86318	115851	132101	153041	12
49	65364	75680	86368	115783	132134	152989	11
50	65386	75661	86419	115715	132168	152938	10
51	65408	75642	86470	115647	132201	152886	9
52	65430	75624	86521	115579	132234	152835	8
53	65452	75604	86572	115511	132267	152783	7
54	65474	75585	86623	115443	132301	152732	6
55	65496	75566	86677	115375	132334	152680	5
56	65518	75547	86728	115308	132368	152630	4
57	65540	75528	86779	115240	132401	152579	3
58	65562	75509	86827	115172	132434	152527	2
59	65584	75490	86878	115104	132468	152476	1
60	65606	75471	86929	115037	132501	152425	0

L 2

49

A TABLE OF

41

Sines

Tangents

Secants

1	65628	75452	86980	114969	132535	152374	59
2	65650	75433	87031	114902	132568	152323	58
3	65672	75414	87082	114834	132602	152273	57
4	65694	75395	87133	114767	132636	152222	56
5	65716	75375	87184	114699	132669	152171	55
6	65738	75356	87236	114632	132703	152120	54
7	65759	75337	87287	114565	132737	152069	53
8	65781	75318	87338	114498	132770	152019	52
9	65803	75299	87389	114430	132804	151968	51
10	65825	75280	87441	114363	132838	151918	50
11	65847	75261	87492	114296	132872	151867	49
12	65869	75241	87543	114229	132905	151817	48
13	65891	75222	87595	114162	132939	151766	47
14	65913	75203	87647	114095	132973	151716	46
15	65935	75184	87698	114028	133007	151665	45
16	65956	75168	87749	113961	133041	151615	44
17	65978	75146	87801	113894	133075	151565	43
18	66000	75126	87852	113828	133109	151515	42
19	66022	75107	87904	113761	133243	151465	41
20	66044	75088	87955	113694	133177	151415	40
21	66066	75069	88007	113627	133211	151364	39
22	66088	75050	88059	113561	133245	151314	38
23	66109	75030	88110	113494	133279	151265	37
24	66131	75011	88162	113428	133314	151215	36
25	66153	74992	88214	113361	133348	151165	35
26	66175	74973	88265	113295	133382	151115	34
27	66197	74953	88317	113229	133416	151066	33
28	66218	74934	88369	113162	133451	151016	32
29	66240	74915	88421	113096	133485	150966	31
30	66262	74896	88473	113029	133519	150916	30

ATABLE OF

	Sines		Tangents		Secants		
41							
31	66284	74876	88524	112963	133554	150866	29
32	66306	74857	88576	112897	133588	150817	28
33	66327	74838	88628	112831	133622	150767	27
34	66349	74818	88681	112765	133657	150718	26
35	66371	74799	88732	112699	133691	150669	25
36	66393	74780	88784	112633	133726	150619	24
37	66414	74760	88836	112567	133761	150570	23
38	66436	74741	88888	112501	133795	150521	22
39	66458	74722	88940	112435	133830	150471	21
40	66480	74703	88992	112369	133864	150422	20
41	66501	74683	89045	112303	133899	150373	19
42	66523	74664	89097	112238	133934	150324	18
43	66545	74644	89149	112172	133968	150275	17
44	66566	74625	89201	112106	134003	150226	16
45	66588	74606	89253	112041	134038	150177	15
46	66610	74586	89306	111975	134073	150128	14
47	66632	74567	89358	111909	134108	150079	13
48	66653	74548	89410	111844	134142	150030	12
49	66675	74528	89463	111778	134177	149981	11
50	66697	74509	89515	111713	134212	149933	10
51	66718	74489	89567	111648	134247	149884	9
52	66740	74470	89620	111582	134282	149835	8
53	66762	74451	89672	111517	134317	149787	7
54	66783	74431	89725	111452	134352	149738	6
55	66805	74412	89777	111387	134387	149690	5
56	66827	74392	89830	111321	134423	149641	4
57	66848	74373	89883	111256	134458	149593	3
58	66870	74353	89935	111191	134493	149544	2
59	66891	74334	89988	111126	134528	149495	1
60	66913	74314	90040	111061	134563	149448	0

A TABLE OF

42

Sines

Tangents

Secants

1	66935	74295	90093	110996	134599	149399	59
2	66956	74276	90146	110931	134634	149351	58
3	66973	74256	90199	110867	134669	149303	57
4	66999	74237	90251	110802	134704	149255	56
5	67021	74217	90304	110737	134740	149207	55
6	67043	74198	90357	110672	134775	149159	54
7	67064	74178	90410	110607	134811	149111	53
8	67086	74159	90463	110543	134846	149063	52
9	67107	74139	90516	110478	134882	149015	51
10	67129	74120	90568	110414	134917	148967	50
11	67151	74100	90621	110349	134953	148919	49
12	67172	74080	90674	110285	134988	148871	48
13	67194	74061	90727	110220	135024	148824	47
14	67215	74041	90781	110156	135060	148776	46
15	67237	74022	90834	110091	135095	148728	45
16	67258	74002	90887	110027	135131	148581	44
17	67280	73983	90940	109963	135167	148633	43
18	67301	73963	90993	109899	135203	148586	42
19	67323	73944	91046	109834	135238	148539	41
20	67345	73924	91099	109770	135274	148491	40
21	67366	73904	91153	109706	135310	148443	39
22	67387	73885	91206	109642	135346	148395	38
23	67409	73865	91259	109578	135382	148349	37
24	67430	73846	91313	109514	135418	148301	36
25	67452	73826	91366	109450	135454	148254	35
26	67473	73806	91419	109386	135490	148207	34
27	67495	73787	91473	109322	135526	148160	33
28	67516	73767	91526	109258	135562	148113	32
29	67538	73747	91580	109195	135598	148066	31
30	67559	73728	91633	109131	135634	148019	30

A TABLE OF

42

	Sines		Tangents		Secants		
31	67580	73708	91687	109067	135670	147922	29
32	67602	73688	91740	109003	135707	147925	28
33	67623	73659	91794	108940	135743	147878	27
34	67645	73649	91847	108876	135779	147831	26
35	67666	73629	91901	108813	135815	147784	25
36	67688	73610	91955	108749	135852	147738	24
37	67709	73590	92008	108686	135888	147691	23
38	67730	73570	92062	108622	135924	147644	22
39	67752	73551	92116	108559	135961	147598	21
40	67773	73531	92170	108496	135997	147551	20
41	67795	73511	92223	108433	136034	147504	19
42	67816	73491	92277	108369	136070	147458	18
43	67837	73472	92331	108306	136107	147411	17
44	67860	73452	92385	108243	136143	147365	16
45	67880	73432	92439	108179	136180	147319	15
46	67901	73412	92494	108116	136217	147272	14
47	67923	73393	92547	108053	136253	147226	13
48	67944	73373	92601	107990	136290	147180	12
49	67965	73353	92655	107927	136327	147134	11
50	68987	73333	92709	107864	136363	147088	10
51	68008	73314	92763	107801	136400	147041	9
52	68029	73294	92817	107738	136437	146995	8
53	68051	73274	92872	107675	136474	146949	7
54	68072	73254	92926	107612	136511	146903	6
55	68093	73234	92980	107550	136548	146857	5
56	68114	73215	93034	107487	136585	146811	4
57	68136	73195	93088	107425	136622	146765	3
58	68157	73175	93143	107362	136659	146719	2
59	68179	73155	93197	107299	136696	146674	1
60	68200	73135	93252	107237	136733	146628	0

A TABLE OF

43

Sines

Tangents

Secants

1	68221	73116	93306	107174	136770	146582	59
2	68242	73096	93360	107112	136807	146537	58
3	68264	73076	93415	107049	136844	146491	57
4	68285	73056	93469	106987	136881	146445	56
5	68306	73036	93524	106925	136919	146400	55
6	68327	73016	93578	106862	136956	146354	54
7	68349	72996	93633	106800	136993	146309	53
8	68370	72976	93688	106738	137030	146263	52
9	68391	72957	93742	106676	137068	146218	51
10	68412	72937	93797	106613	137105	146173	50
11	68433	72917	93852	106551	137143	146127	49
12	68455	72897	93906	106489	137180	146082	48
13	68476	72877	93961	106427	137218	146037	47
14	68497	72857	94016	106365	137255	145992	46
15	68518	72837	94071	106303	137293	145946	45
16	68539	72817	94125	106241	137330	145901	44
17	68561	72797	94181	106179	137368	145856	43
18	68582	72777	94235	106117	137406	145811	42
19	68603	72757	94290	106056	137443	145766	41
20	68624	72737	94345	105993	137481	145721	40
21	68645	72717	94400	105932	137519	145672	39
22	68666	72697	94455	105870	137556	145631	38
23	68688	72677	94510	105809	137594	145587	37
24	68709	72657	94565	105747	137632	145542	36
25	68730	72637	94620	105685	137670	145497	35
26	68751	72617	94676	105624	137708	145452	34
27	68772	72597	94731	105562	137746	145408	33
28	68793	72577	94786	105501	137782	145363	32
29	68814	72557	94841	105439	137822	145319	31
30	68835	72537	94896	105378	137860	145274	30

A TABLE OF

43

	Sines		Tangents		Secants		
31	68857	72517	94952	105317	137898	145229	29
32	68878	72497	95007	105255	137936	145185	28
33	68899	72477	95062	105194	137974	145141	27
34	68920	72457	95118	105133	138012	145096	26
35	68941	72437	95173	105072	138051	145052	25
36	68962	72417	95228	105010	138089	145007	24
37	68983	72397	95284	104949	138127	144963	23
38	69004	72377	95340	104888	138165	144919	22
39	69025	72357	95395	104827	138204	144875	21
40	69046	72337	95451	104766	138242	144831	20
41	69067	72317	95506	104704	138280	144786	19
42	69088	72297	95562	104644	138319	144742	18
43	69109	72277	95618	104583	138357	144698	17
44	69130	72257	95673	104522	138396	144654	16
45	69151	72236	95729	104461	138434	144610	15
46	69172	72216	95785	104401	138473	144566	14
47	69193	72196	95841	104340	138512	144523	13
48	69214	72176	95897	104279	138550	144479	12
49	69235	72156	95952	104218	138589	144435	11
50	69256	72136	96008	104158	138628	144391	10
51	69277	72116	96064	104097	138666	144347	9
52	69298	72095	96120	104036	138705	144304	8
53	69319	72075	96176	103976	138744	144260	7
54	69340	72055	96232	103915	138783	144216	6
55	69361	72035	96288	103855	138822	144173	5
56	69382	72015	96344	103794	138860	144129	4
57	69402	71995	96400	103734	138899	144086	3
58	69424	71974	96457	103674	138938	144042	2
59	69445	71954	96513	103613	138977	143999	1
60	69466	71934	96569	103552	139016	143956	0

M

46

A TABLE OF

44

Sines

Tangents

Secants

1	69487	71914	96625	103493	139055	143912	59
2	69508	71894	96681	103433	139095	143869	58
3	69529	71873	96738	103372	139134	143826	57
4	69549	71853	96794	103312	139173	143783	56
5	69570	71833	96850	103252	139212	143739	55
6	69591	71813	96907	103192	139251	143696	54
7	69612	71792	96963	103132	139291	143653	53
8	69633	71772	97020	103072	139330	143610	52
9	69654	71752	97076	103012	139369	143567	51
10	69675	71732	97133	102952	139409	143524	50
11	69696	71711	97189	102892	139448	143481	49
12	69717	71691	97246	102832	139487	143438	48
13	69737	71671	97302	102772	139527	143395	47
14	69758	71650	97359	102713	139566	143352	46
15	69779	71630	97416	102653	139606	143309	45
16	69800	71610	97472	102593	139645	143267	44
17	69821	71590	97529	102533	139685	143224	43
18	69842	71569	97586	102474	139725	143181	42
19	69862	71549	97643	102414	139764	143139	41
20	69883	71529	97700	102355	139804	143096	40
21	69904	71508	97756	102295	139844	143053	39
22	69925	71488	97813	102236	139884	143011	38
23	69946	71468	97870	102176	139924	142968	37
24	69966	71447	97927	102117	139963	142926	36
25	69987	71427	97984	102057	140003	142883	35
26	70008	71407	98041	101998	140043	142841	34
27	70029	71386	98098	101939	140083	142799	33
28	70049	71366	98155	101879	140123	142756	32
29	70070	71345	98213	101820	140163	142714	31
30	70091	71325	98270	101761	140203	142672	30

A TABLE OF

44

	Sines		Tangents		Secants		
31	70112	71305	98327	101702	140243	142630	29
32	70132	71284	98384	101642	140283	142587	28
33	70153	71264	98441	101583	140324	142545	27
34	70174	71244	98499	101524	140364	142503	26
35	70195	71223	98556	101465	140404	142461	25
36	70215	71203	98613	101406	140444	142419	24
37	70236	71182	98671	101347	140485	142377	23
38	70257	71162	98728	101288	140525	142335	22
39	70278	71141	98786	101229	140565	142293	21
40	70298	71121	98843	101170	140606	142251	20
41	70319	71100	98901	101112	140646	142209	19
42	70339	71080	98958	101053	140687	142168	18
43	70360	71059	99016	100994	140727	142126	17
44	70381	71039	99073	100935	140768	142084	16
45	70401	71019	99131	100876	140808	142042	15
46	70422	70998	99189	100818	140849	142001	14
47	70443	70978	99247	100759	140890	141959	13
48	70463	70957	99304	100701	140930	141918	12
49	70484	70937	99362	100642	140971	141876	11
50	70505	70916	99420	100583	141012	141835	10
51	70525	70896	99478	100525	141053	141793	9
52	70546	70875	99536	100467	141093	141752	8
53	70567	70855	99594	100408	141134	141710	7
54	70587	70834	99652	100350	141175	141669	6
55	70608	70813	99710	100291	141216	141628	5
56	70628	70793	99768	100233	141257	141586	4
57	70649	70772	99826	100175	141298	141545	3
58	70670	70752	99884	100116	141339	141504	2
59	70690	70731	99942	100058	141380	141463	1
60	70711	70711	00000	100000	141421	141421	0

M 2

45